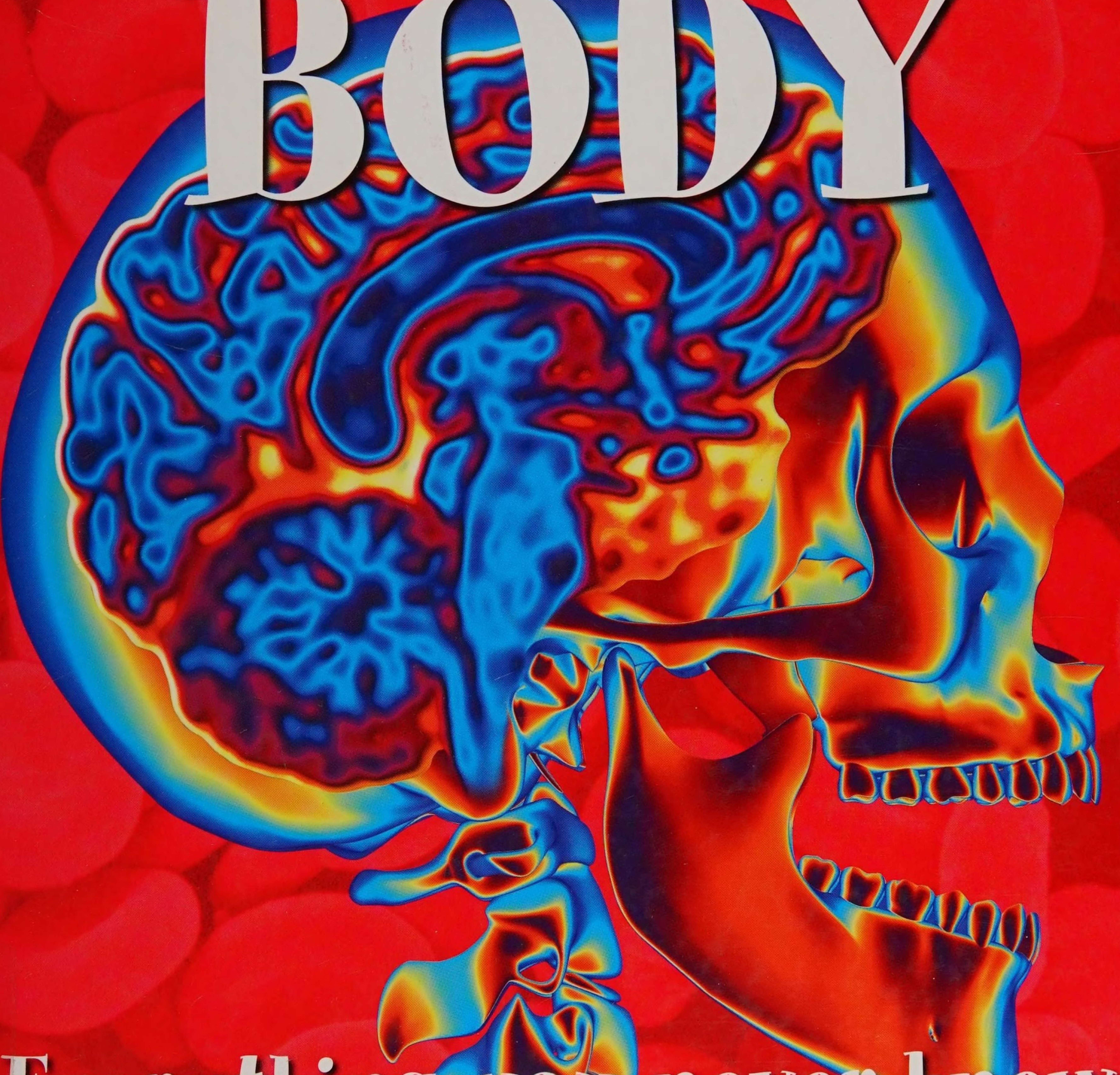
DK

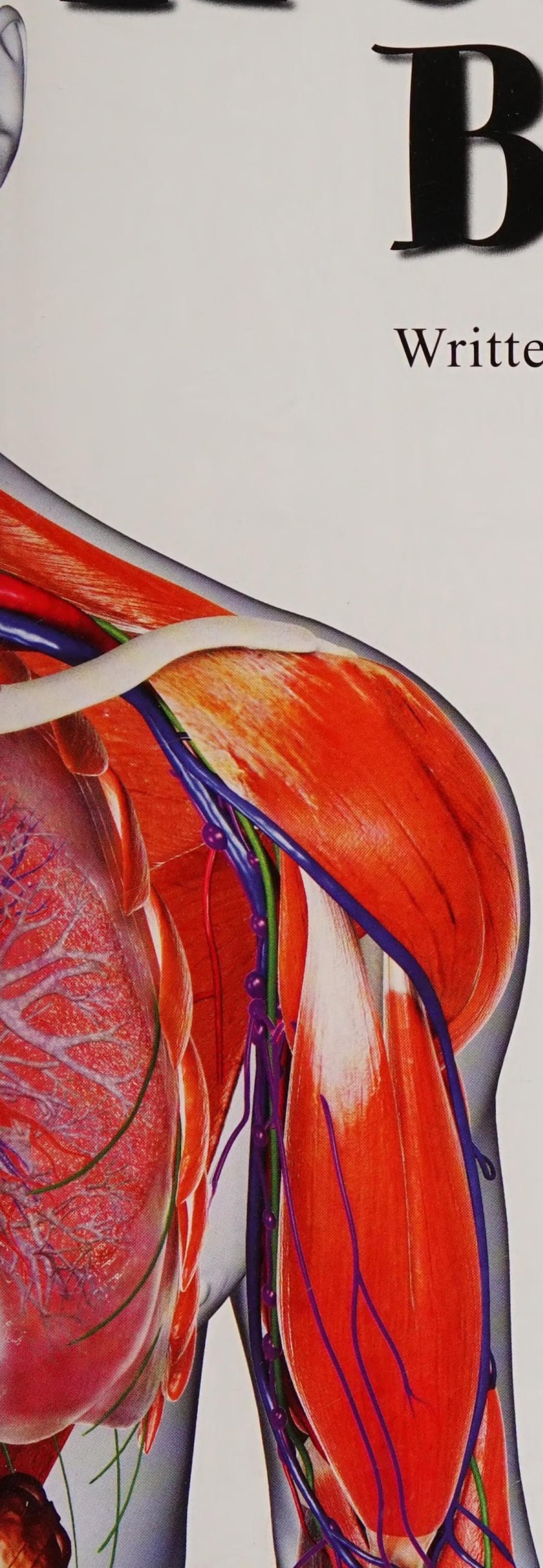
HUMAN BODY



Everything you never knew about the human body

HUMAN BODY

Written by Richard Walker



DK

LONDON, NEW YORK,
MELBOURNE, MUNICH, AND DELHI

Senior Art Editor Smiljka Surla
Designer Hoa Luc
Senior Editor Fran Jones
Project Editor Niki Foreman
Additional Designers Sheila Collins, Spencer Holbrook, Stefan Podhorodecki, Marilou Prokopiou, Jacqui Swan
Editorial Assistant Ashwin Khurana
Managing Editor Linda Esposito
Managing Art Editor Diane Thistlethwaite

Publishing Manager Andrew Macintyre
Category Publisher Laura Buller
Design Development Manager Sophia M Tampakopoulos
Production Controller Poppy Newdick
Production Editor Melissa Latorre
DK Picture Library Ria Jones
Jacket Editor Mariza O'Keeffe
Jacket Designer Laura Brim

First published in Great Britain in 2010
by Dorling Kindersley Limited,
80 Strand, London WC2R 0RL

A Penguin Company

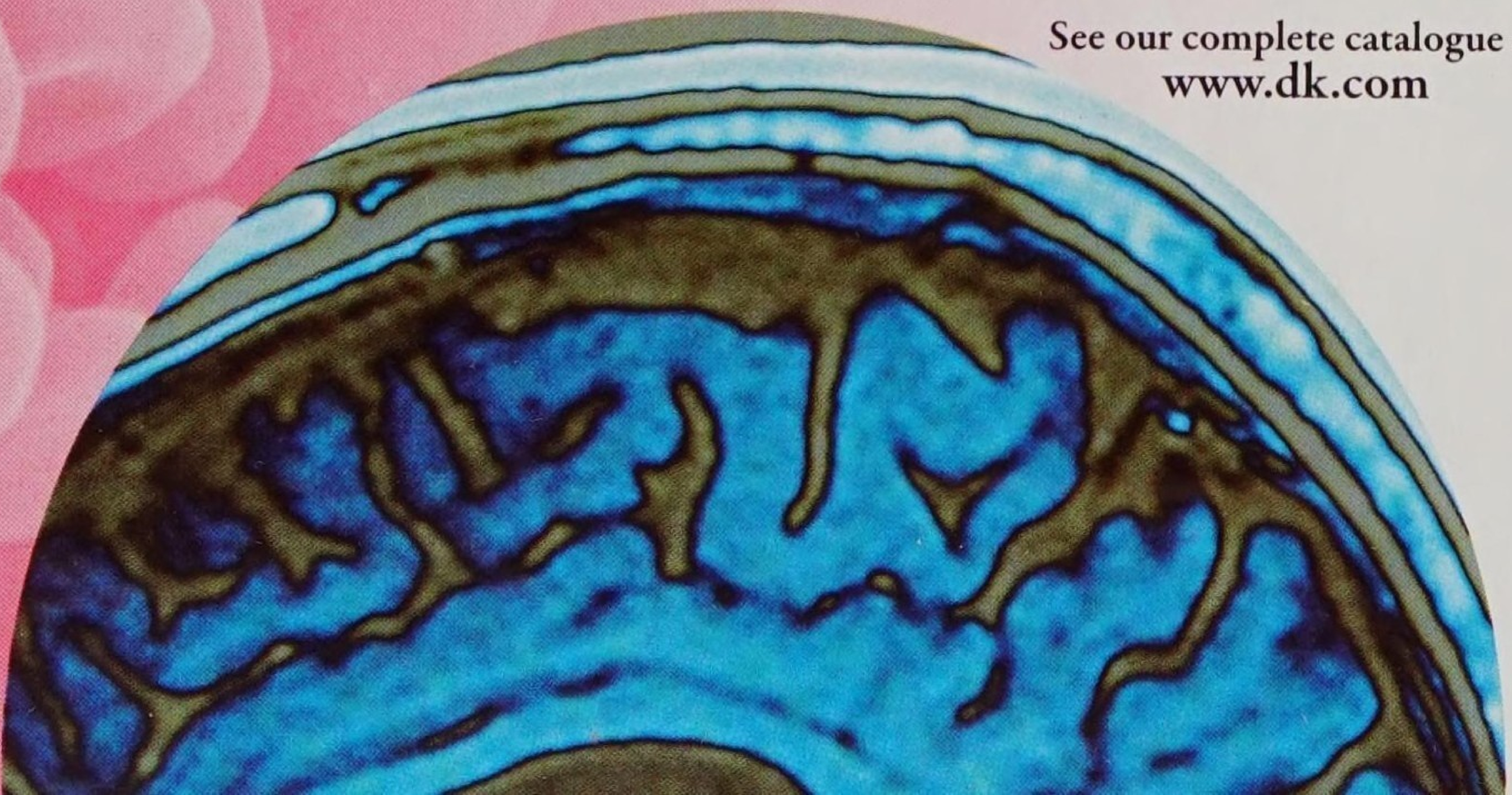
2 4 6 8 10 9 7 5 3 1
HD171 – 11/09

A CIP catalogue record for this book is available from the British Library.

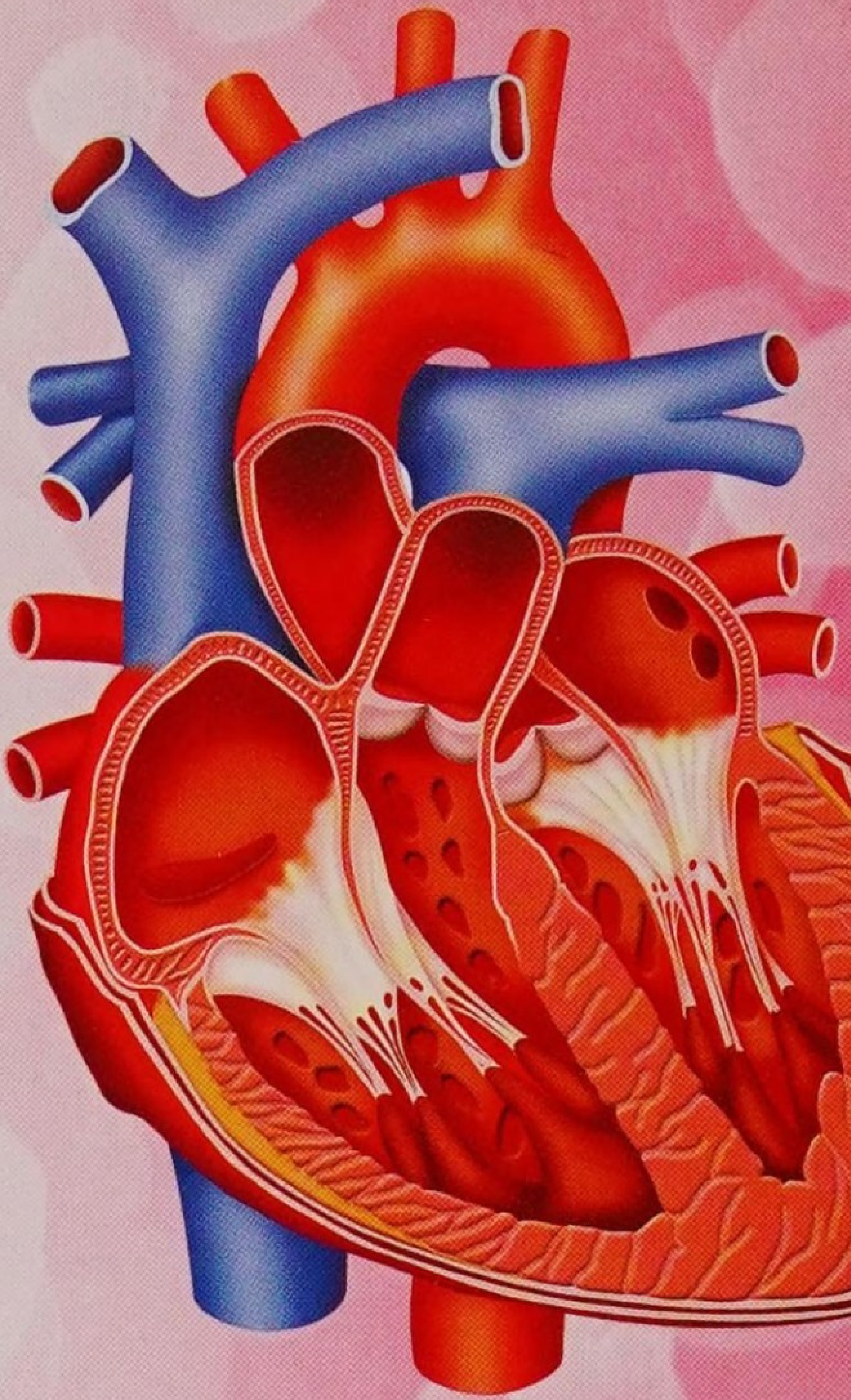
ISBN 978-1-40533-668-0

Printed and bound in China by Toppan

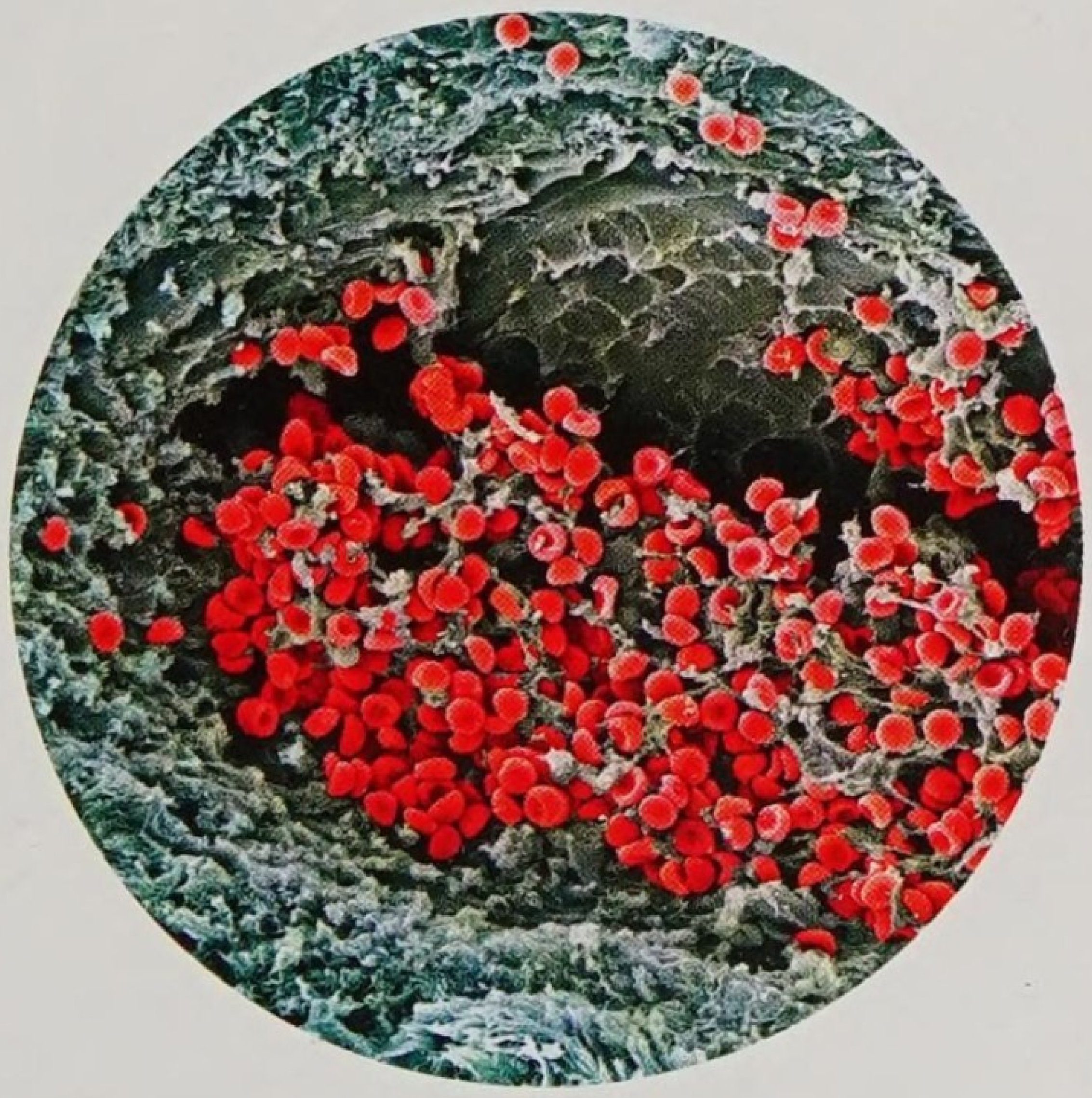
See our complete catalogue at
www.dk.com







CONTENTS




Body parts

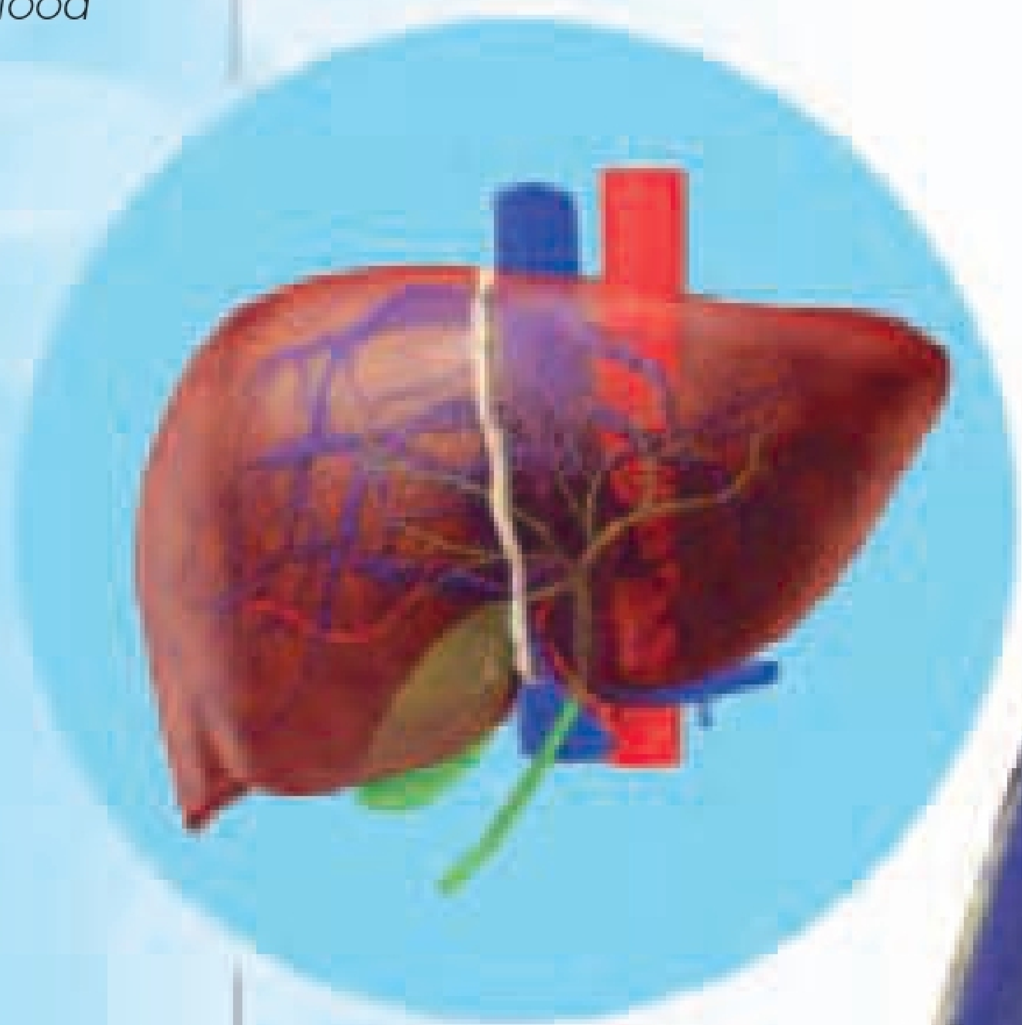
What is my body made from?

It takes about 100 trillion (100,000,000,000,000) microscopic living units called cells to make a human body. There are many different types of cells, and these are organized into the tissues and organs that make up your major body systems. These include the skeletal and muscular systems, which support and move the body, and the digestive and respiratory systems, which supply food and oxygen.

Circulatory system

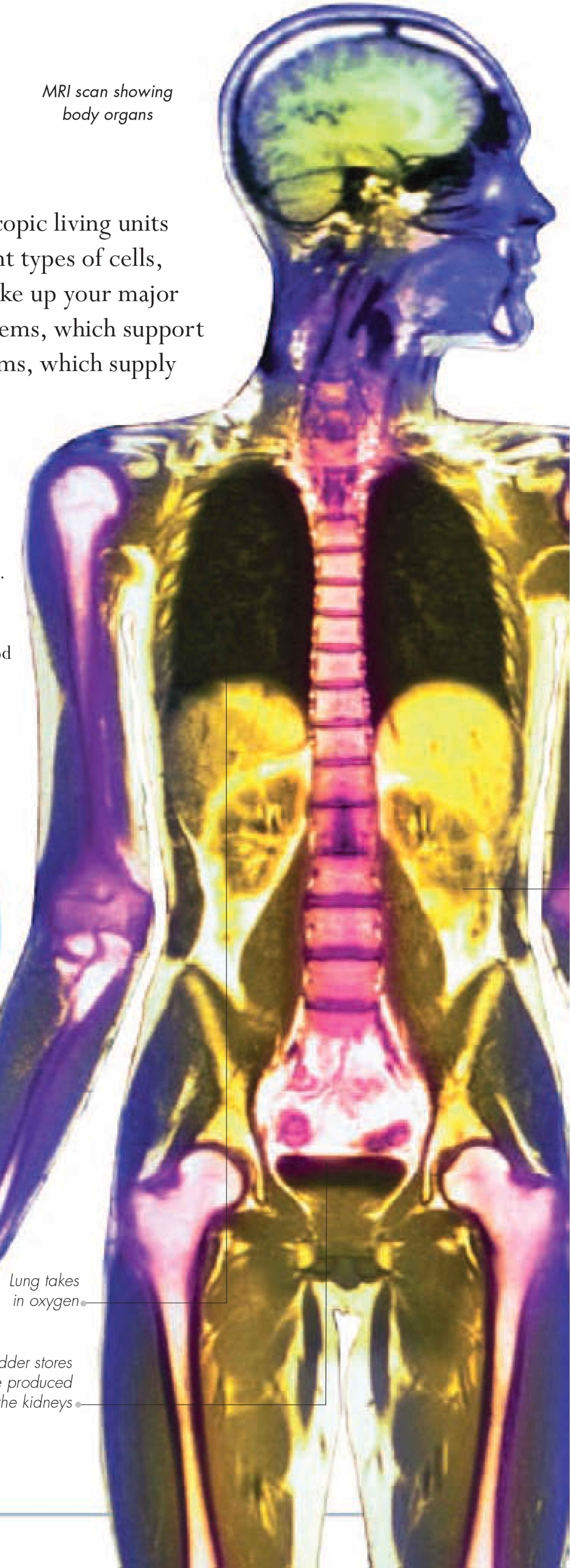
Which is my biggest organ?

Your organs come in many shapes and sizes and perform many different roles. Your organs include skin – your body's biggest organ – the liver, which controls blood composition, the lungs, and kidneys. Each organ has specific tasks.


The liver – the body's second biggest organ

How does my body work?

At the simplest level, cells of the same type work together in groups to form tissues. Different tissues co-operate to make organs, such as the heart, and linked organs work together to form one of the body's 12 systems. In the circulatory system, for example, the heart and blood vessels work together to transport blood all around the body.


MRI scan showing body organs

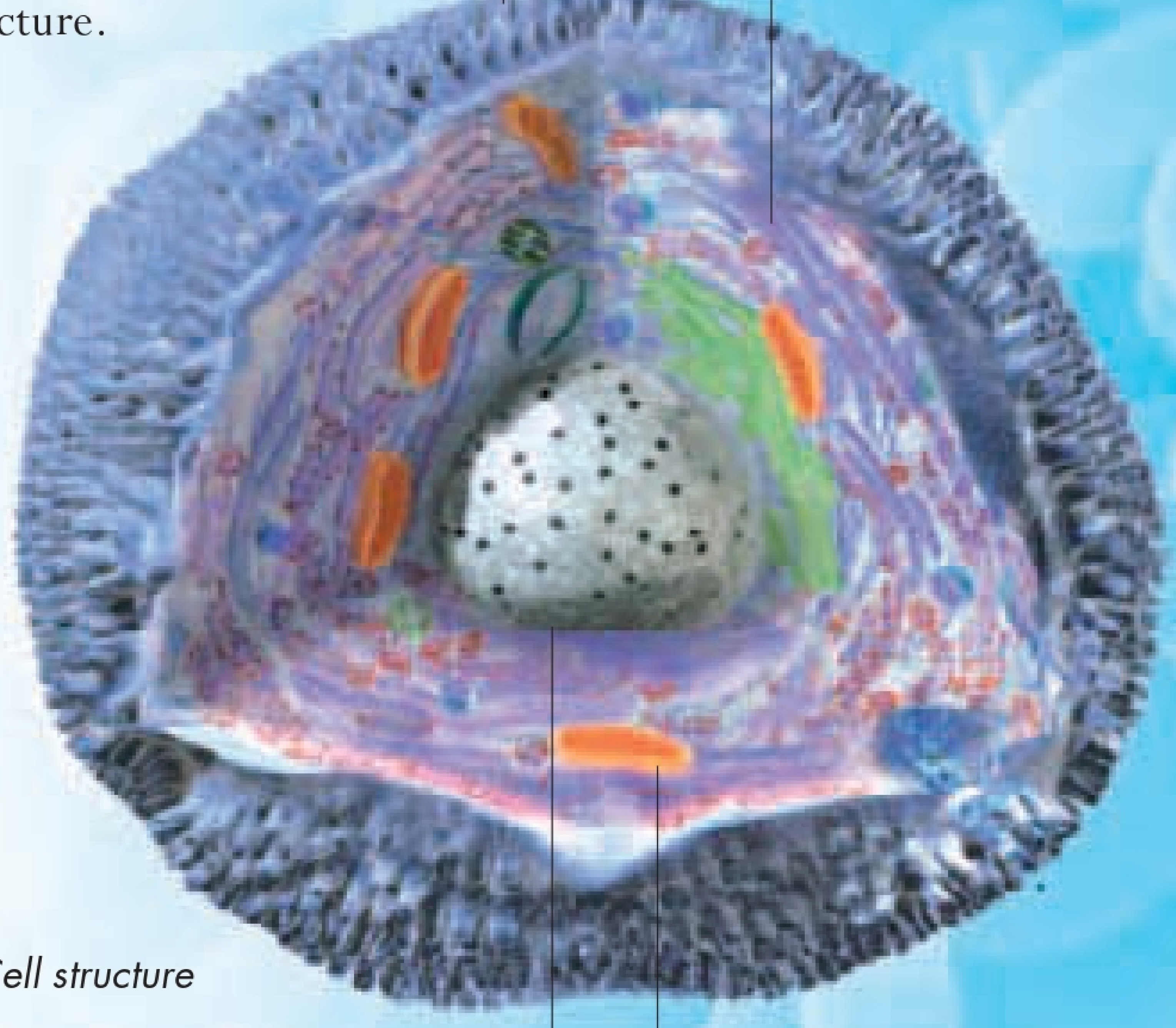
Connective tissue fibres

What holds my body together?

Q **A** There are four basic types of tissues in your body – epithelial, nervous, muscular, and connective. Epithelial tissues are protective; they cover the skin and line the mouth, stomach, and other organs. Nervous tissues form your body's control system – the brain and nervous system. Muscular tissues form the muscles that move you. And connective tissues, as their name suggests, hold other tissues and your body together.

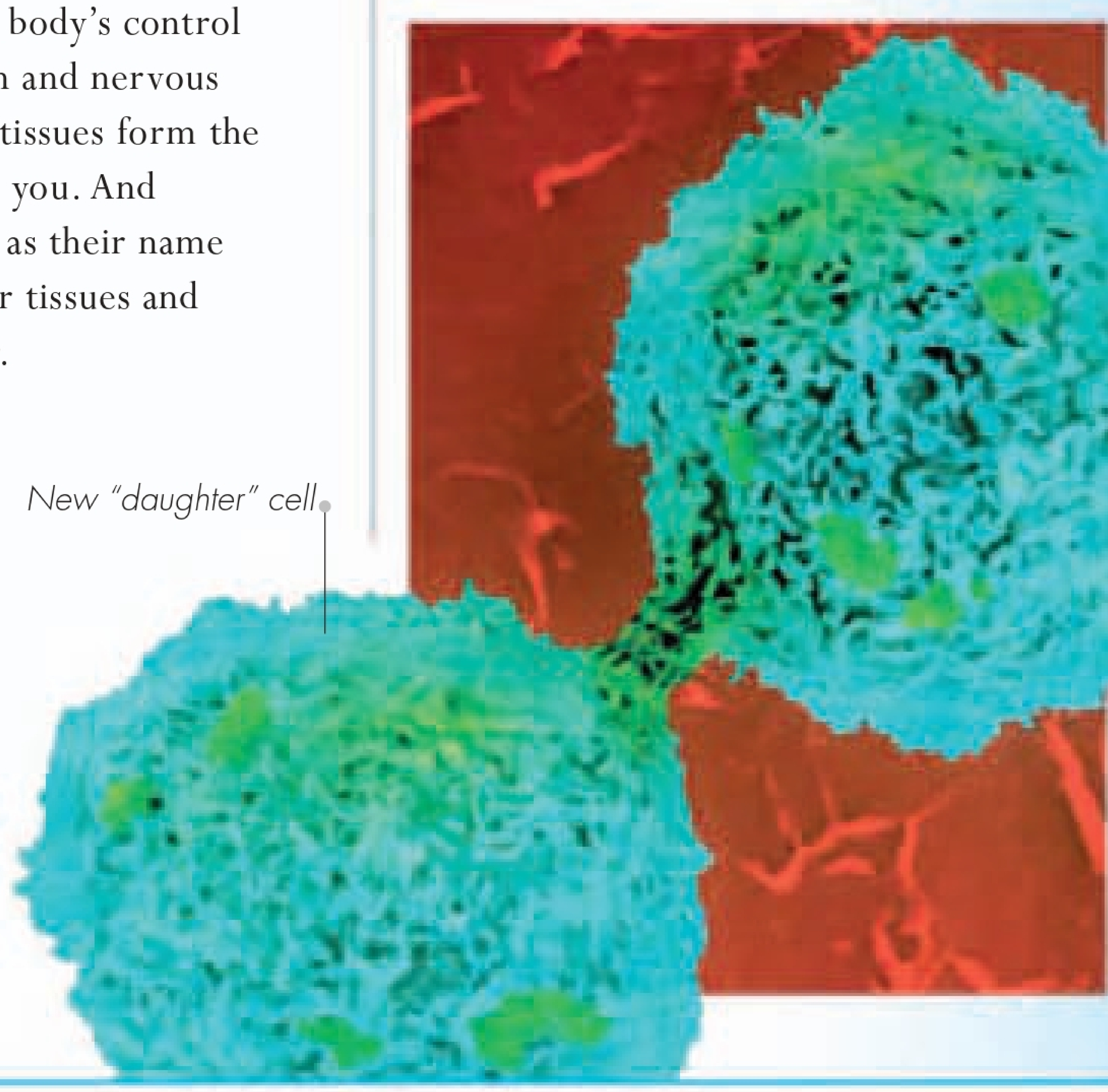
Are cells alive?

Q **A** Although they are microscopic, cells have a complex structure. A membrane surrounds the cell and controls what enters and leaves it. Below this, a jelly-like cytoplasm has tiny structures, called organelles, floating and moving in it. Organelles each have their own jobs, but they work together to make the cell a living unit. For example, mitochondria release energy to power the cell's activities. The nucleus contains the cell's operating instructions.



Cell structure

Cell division



How do cells multiply?

Q **A** Right now, some of your cells are dividing by a process called mitosis. Highly organized and precisely timed, mitosis enables your cells to multiply so that you can grow, maintain yourself, and replace worn-out cells. During mitosis the instructions inside the nucleus, which are needed to build and run a cell, are copied and separated into two equal packages. Then the "parent" cell divides into two identical "daughter" cells, each with its own complete instruction set.

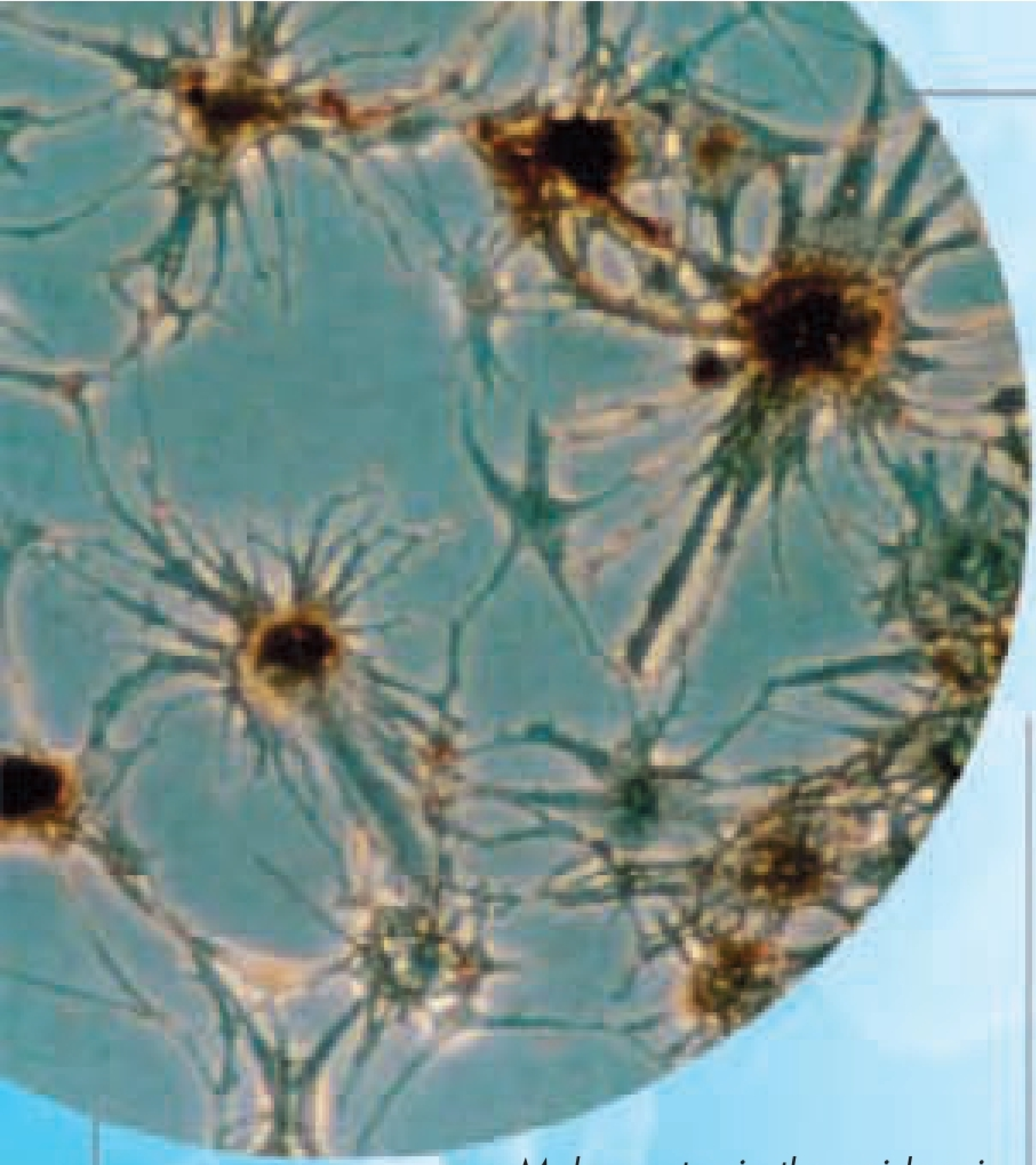
Stem cell

More Facts

- There are more than 200 different types of cells in the body including red blood cells, nerve cells, fat cells, and muscle cells.
- A cell lining the small intestine has a lifespan of just 36 hours, while a red blood cell lives for four months, and a brain cell can last a lifetime.
- An egg, or ovum, released from a woman's ovary, is at least 0.1 mm (0.0039 in) across and the biggest cell in the body.
- Stem cells are found in various body tissues. They multiply rapidly to produce cells that become specialized to do a specific job. In red bone marrow, for example, stem cells produce blood cells.

Is skin alive?

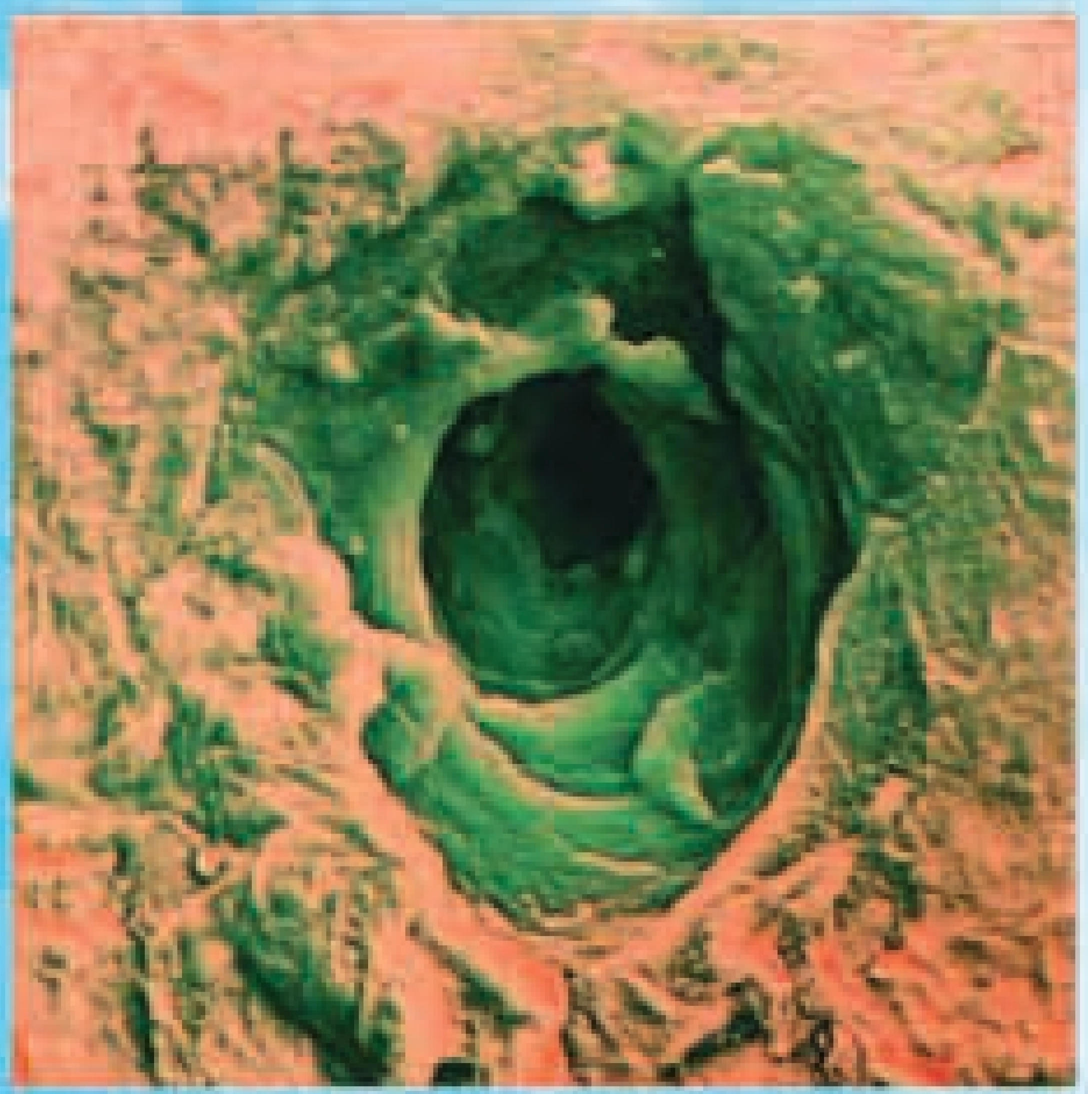
Enclosing your body like an overcoat, skin is a tough, waterproof, germ-proof barrier that separates your insides from the harsh outside world. It also houses receptors that detect touch, pressure, heat, cold, and pain. The skin has two parts: the epidermis and the dermis. The protective epidermis constantly produces cells that migrate upwards to the skin's surface where they flatten, die, and are worn away as skin flakes. Very much alive, the lower dermis contains blood vessels, hair follicles, sweat glands, and sensory receptors.



Melanocytes in the epidermis

Q What makes skin the colour it is?

A Deep in the epidermis, cells called melanocytes release melanin – a brown pigment that colours your skin. Melanin also filters out harmful ultraviolet radiation in sunlight that can damage skin cells. We all have the same number of melanocytes but they produce more melanin in people with darker skin.



Sweat pore

Q Why do I sweat when it's hot?

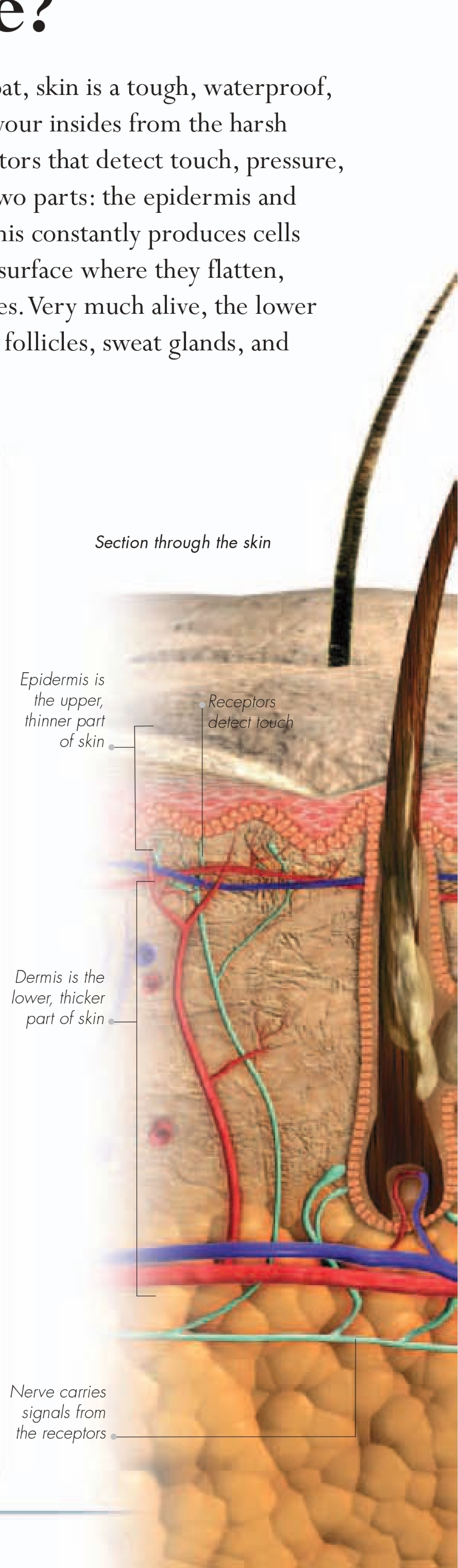
A Your skin helps to keep your body temperature at a steady 37°C (98.6°F). If it's hot, sweat released onto your skin's surface evaporates and cools you down. At the same time blood vessels near the skin's surface widen and release heat. If it's cold you stop sweating and those blood vessels narrow to cut heat loss.

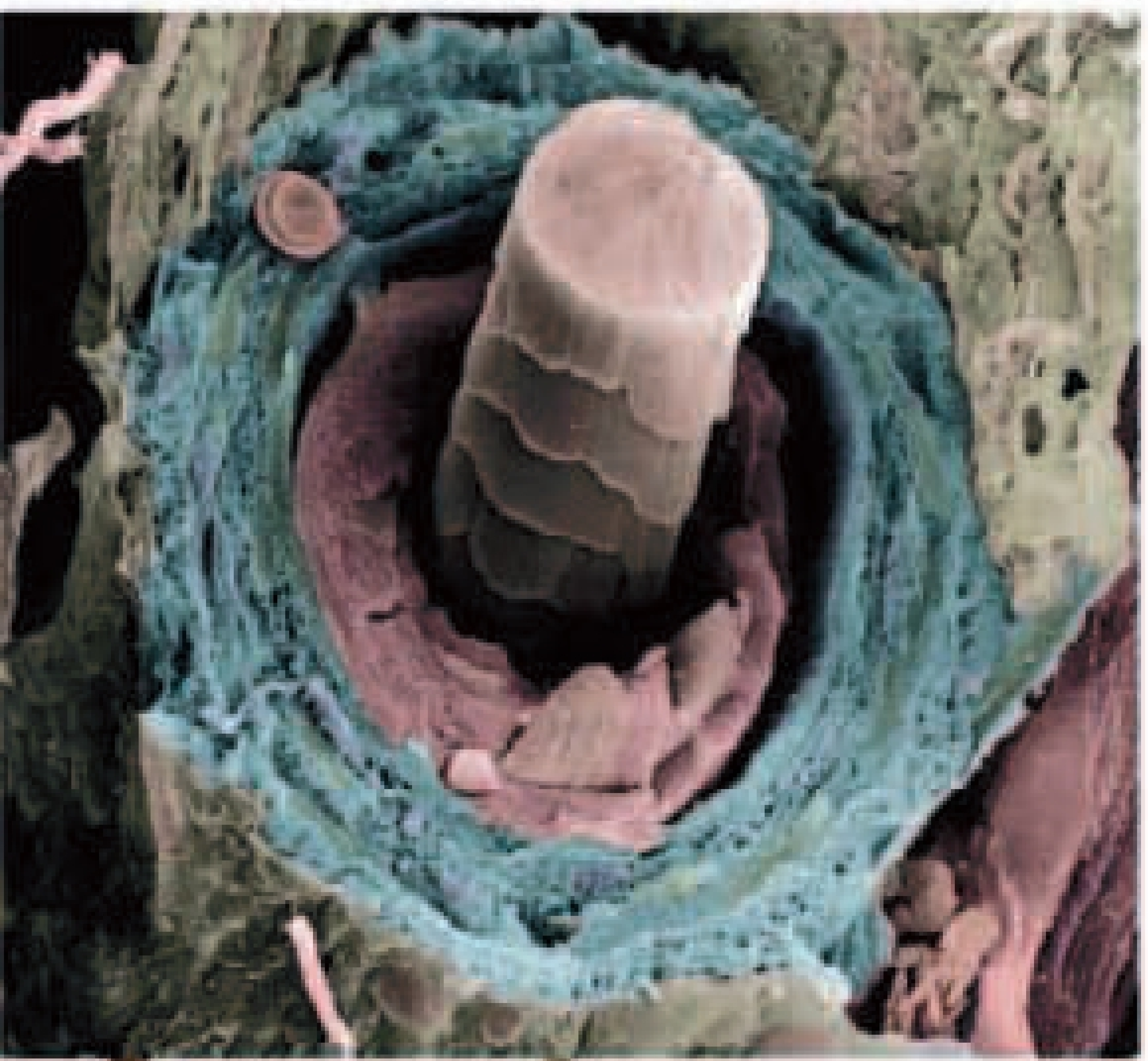
Fingerprint

Q What makes my fingerprints unique?

A Tiny, swirling ridges on your fingers help you to grip things. They also leave behind sweaty patterns called fingerprints. These ridges form before you are born, shaped by the conditions around you in your mother's uterus. Those conditions are different for each person, even identical twins, making your fingerprints unique.

Section through the skin

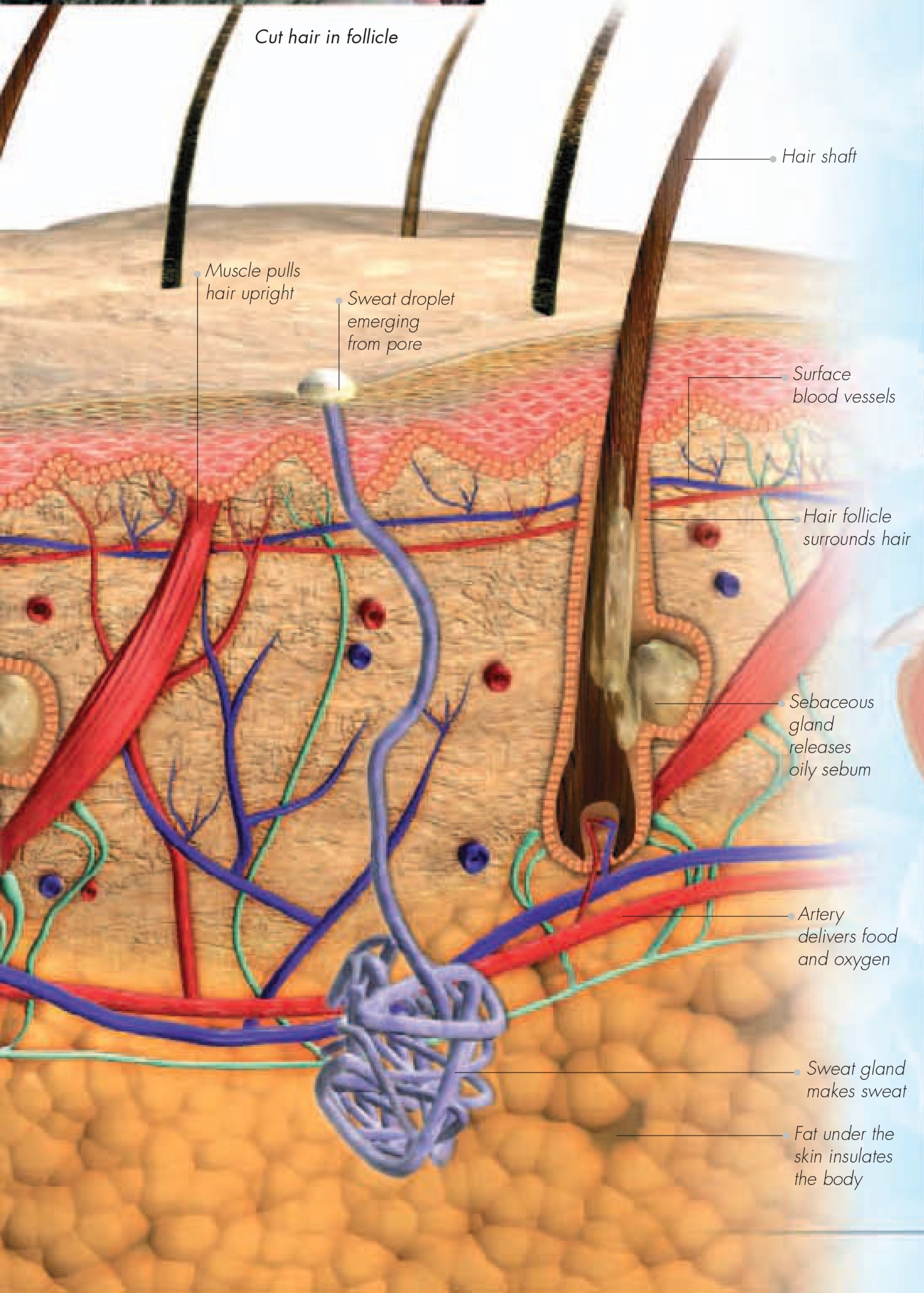




Cut hair in follicle

Q A Why is a haircut painless?

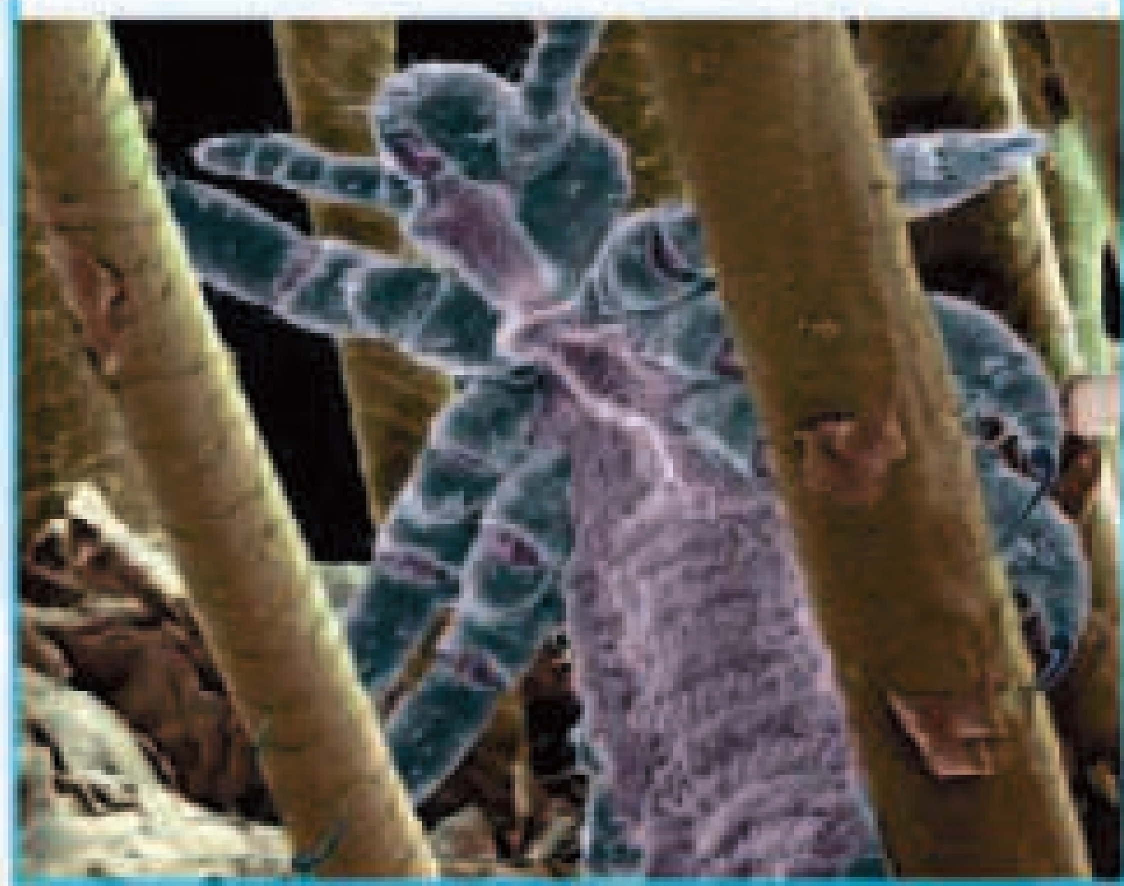
Hairs, nails, and the upper layer of the epidermis all have something in common: Although they are produced by living cells, they consist mostly of dead cells packed with a strong and waterproof protein called keratin. The shaft of the hair is made of dead cells, so having your hair cut doesn't hurt. Trimming your nails is also painless for the same reason.

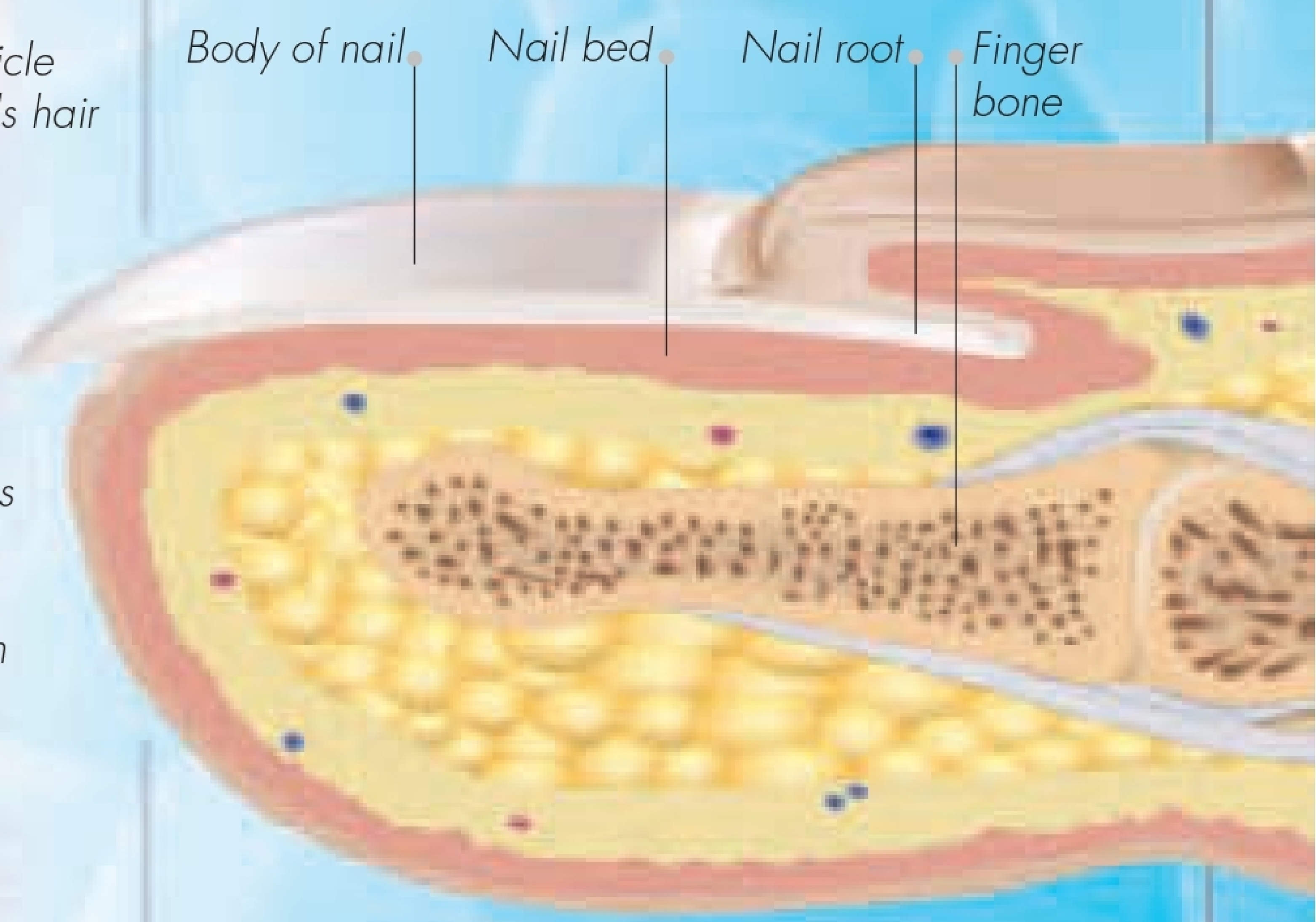


More Facts

- Although very thin, at 5 kg (11 lbs) skin is the heaviest body organ, despite losing 50,000 skin flakes every minute.
- You have approximately 100,000 head hairs that grow about 10 mm (0.4 in) every month. Between 75 and 100 head hairs are lost and replaced daily.
- Head lice are small, wingless insects, common among school children, that grip hairs with their pincers and pierce the scalp to feed on blood.

Head louse gripping hairs





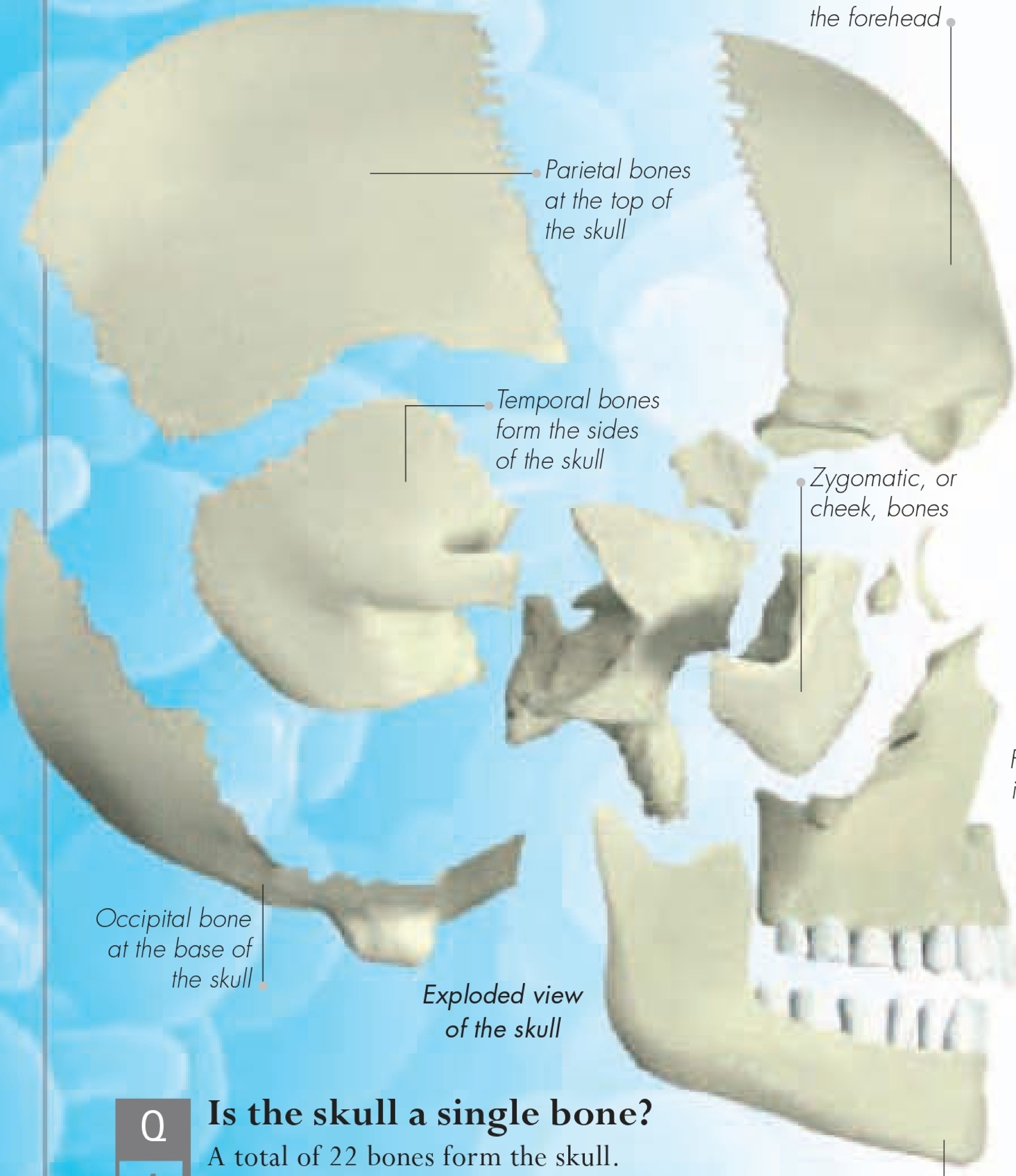
Section through a fingertip

Q A How quickly do fingernails grow?

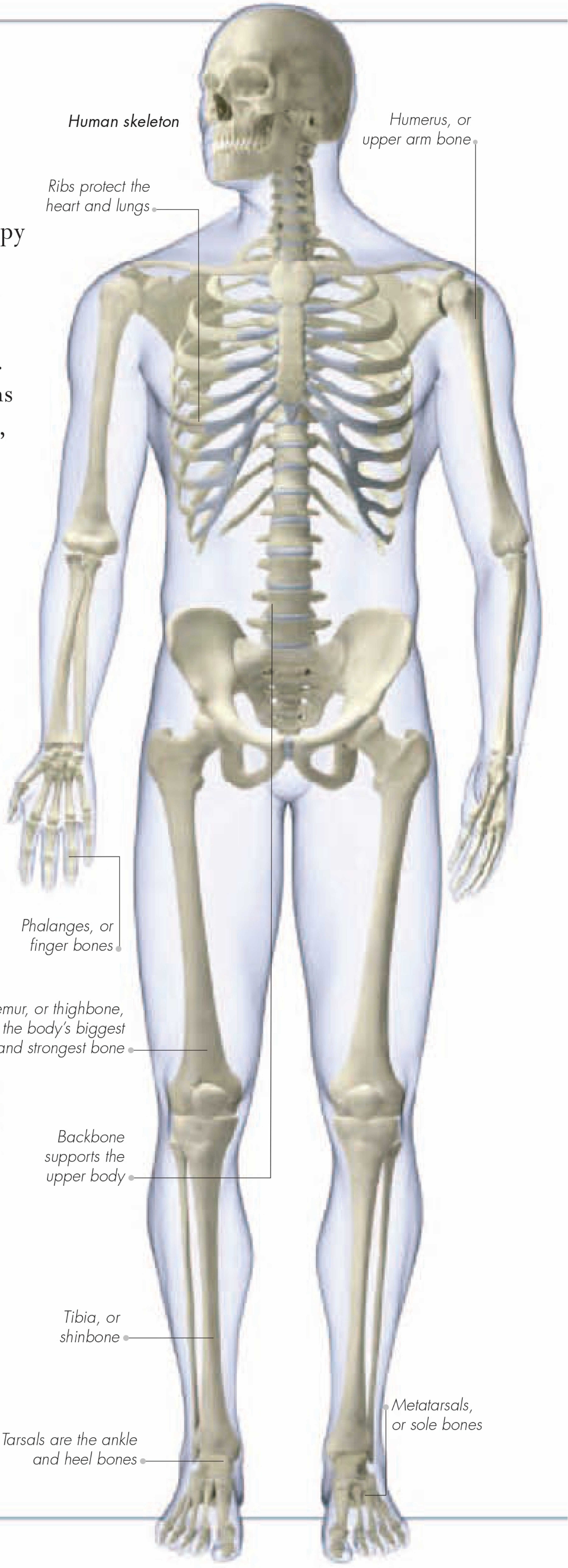
Nails protect fingertips, help pick up small objects, and scratch itches. Growing from the nail root, the body of the nail slides forwards over the nail bed, growing by about 5 mm (0.2 in) a month in summer, but more slowly in winter.

How many bones do I have?

Without its skeleton, your body would collapse in a floppy heap. This supportive framework is constructed from 206 bones and makes up about 20 per cent of your body weight. Each bone is a living organ with a structure that makes it as strong as steel but at a fraction of the weight. Your skeleton also surrounds and protects delicate organs such as the brain and heart and, when pulled by muscles, makes you move.



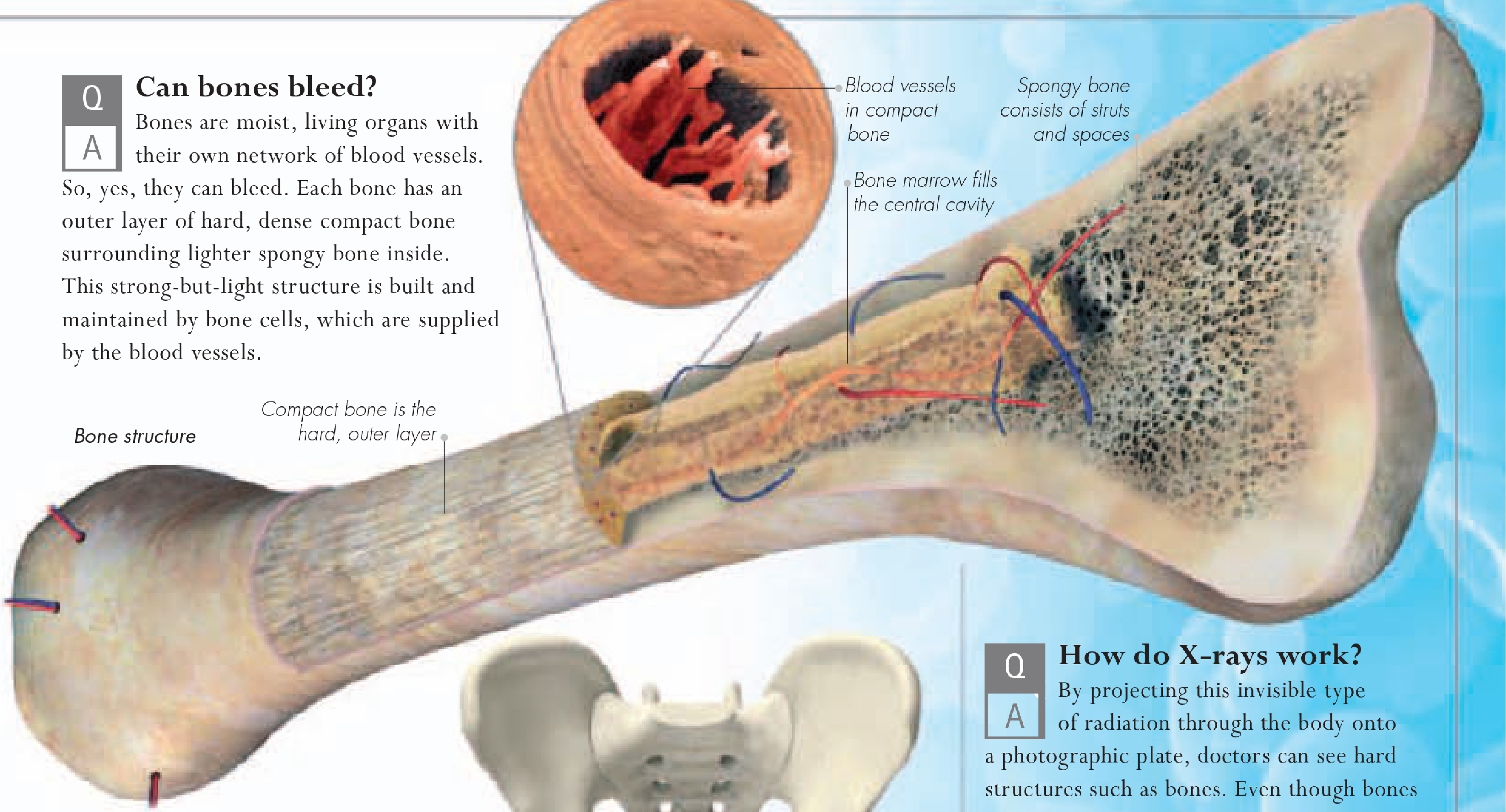
Exploded view of the skull



Human skeleton

Q Is the skull a single bone?

A A total of 22 bones form the skull. Eight of those bones, including the occipital and frontal bones, surround, support, and protect your brain. The other 14 bones, including the zygomatic bones, form the framework of your face. Most skull bones are locked together by immovable joints called sutures. Only the mandible moves, allowing you to eat, breathe, and speak.



Bone structure

Q Can bones bleed?

A Bones are moist, living organs with their own network of blood vessels. So, yes, they can bleed. Each bone has an outer layer of hard, dense compact bone surrounding lighter spongy bone inside. This strong-but-light structure is built and maintained by bone cells, which are supplied by the blood vessels.

Q Are male and female skeletons the same?

A You can distinguish between male and female skeletons by looking at the pelvis. This basin-shaped structure attaches the thighbones to the body and supports organs in the abdomen. In women, the opening in the centre of the pelvis is wider than in men. This provides room for a baby's head to squeeze through during birth.

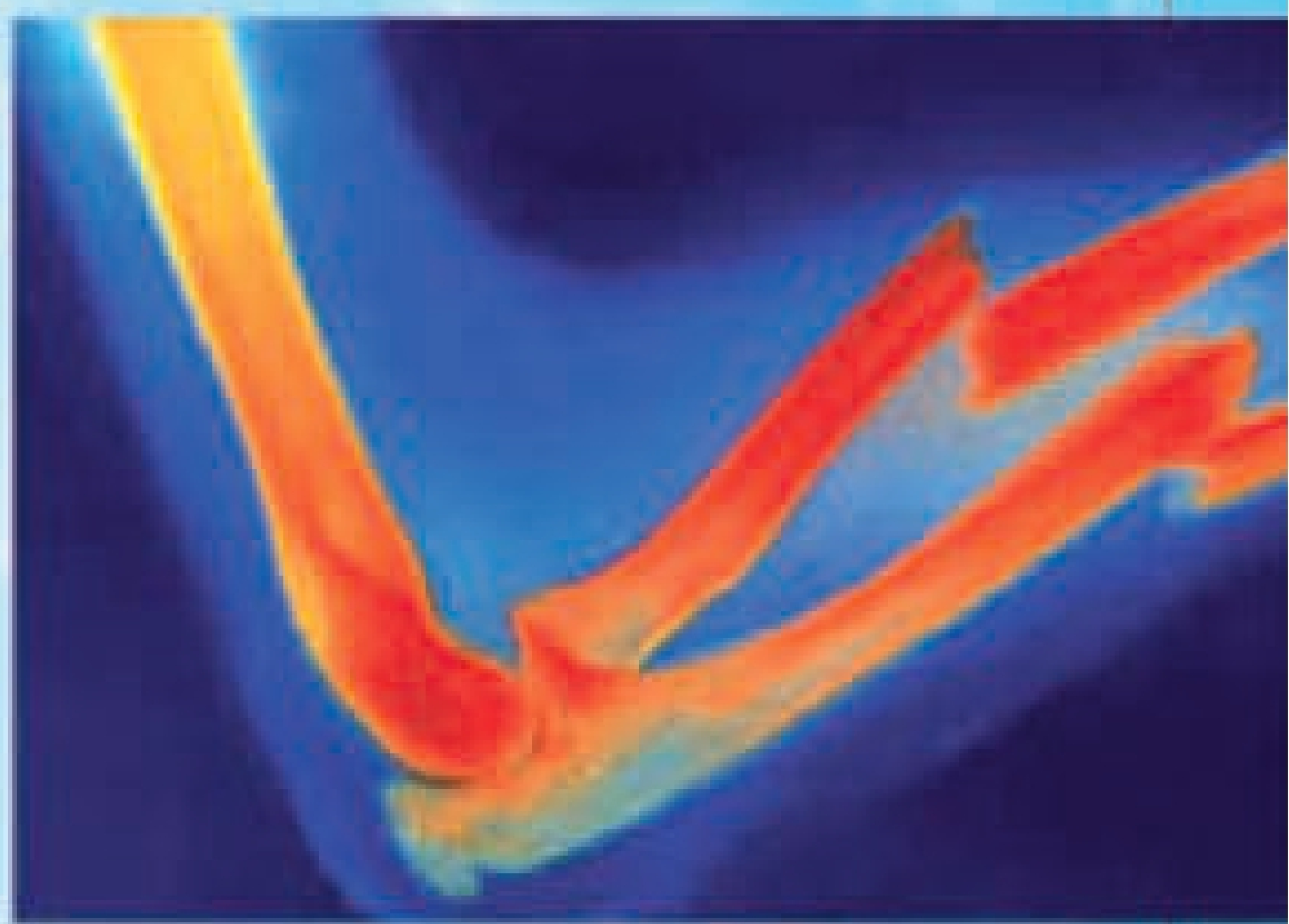

Male pelvis


Female pelvis

Q How do X-rays work?

A By projecting this invisible type of radiation through the body onto a photographic plate, doctors can see hard structures such as bones. Even though bones are very tough, fractures can happen if, say, they suffer a sudden impact.

Artificially coloured X-ray of fractured arm bones



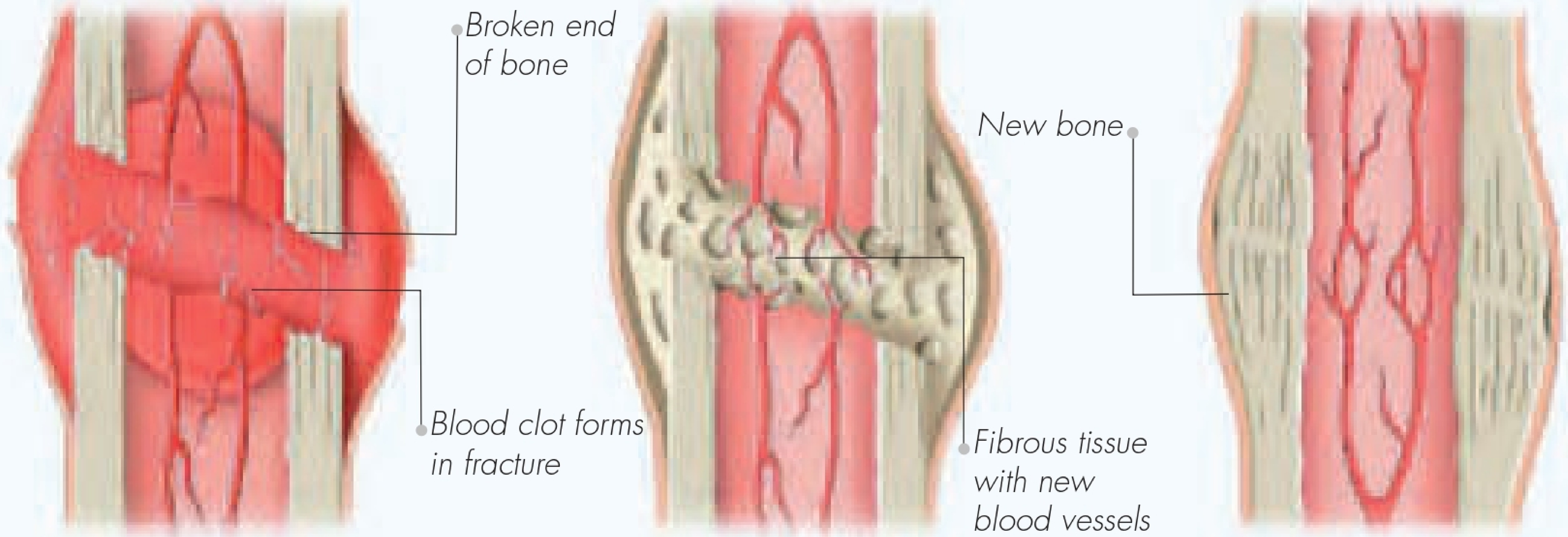
How do bones heal themselves?

If a bone is fractured, a self-repair system springs into action immediately. Blood leaking from damaged blood vessels clots to stop further bleeding. Then the rebuilding process, which takes weeks or months, gets under way. Doctors often line up the broken ends of the bones to make sure that the repair works properly and is not the wrong shape.

1 Within hours of the fracture, a blood clot forms between bone ends, sealing off cut blood vessels.

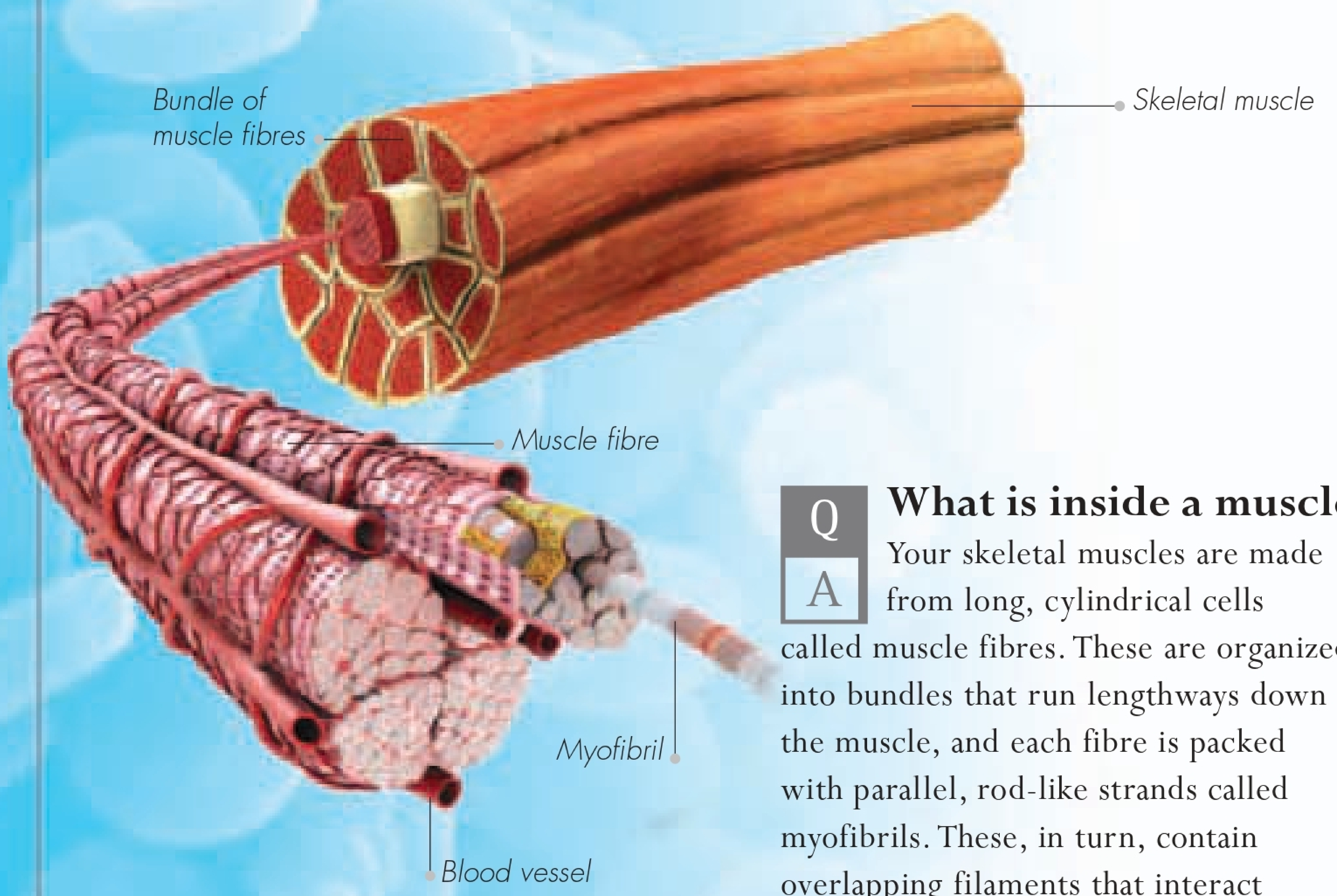
2 After three weeks, fibrous tissue replaces the clot. New blood vessels supply bone-building cells.

3 After three months, new bone has replaced the fibrous tissue and the repair is almost complete.



Why are muscles so important?

Eating your lunch or riding a bike would be impossible without muscles. They produce every that movement you make. Muscles are unique in their ability to contract, or get shorter, to create pulling power. There are three types of muscles. Skeletal muscles pull bones to move your body. Smooth muscles squeeze the walls of organs to, for example, push food along the small intestine. Cardiac muscle, found only in the heart, pumps blood.



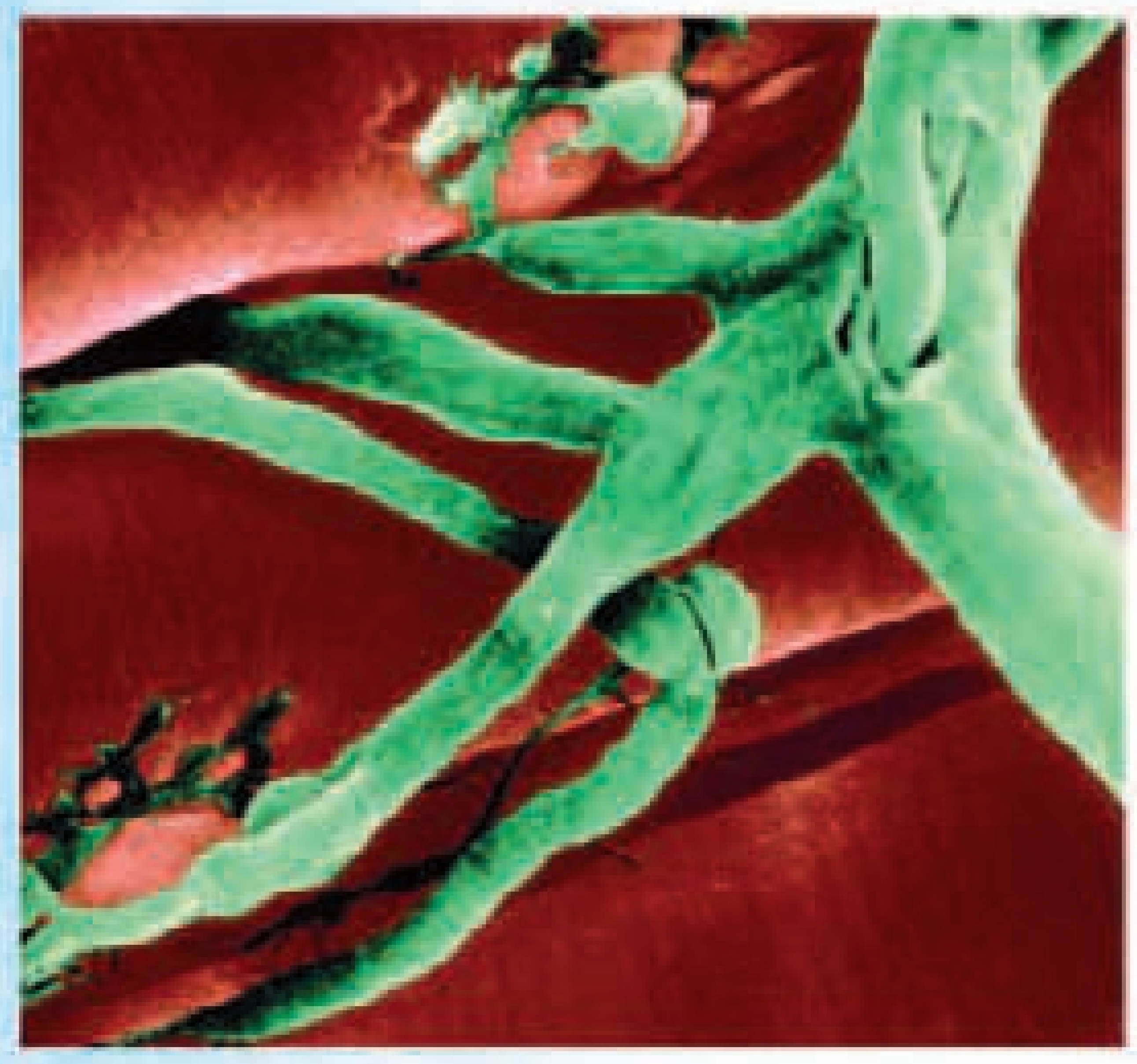
Skeletal muscle structure

Q/A What is inside a muscle?

Your skeletal muscles are made from long, cylindrical cells called muscle fibres. These are organized into bundles that run lengthways down the muscle, and each fibre is packed with parallel, rod-like strands called myofibrils. These, in turn, contain overlapping filaments that interact to make muscles contract.

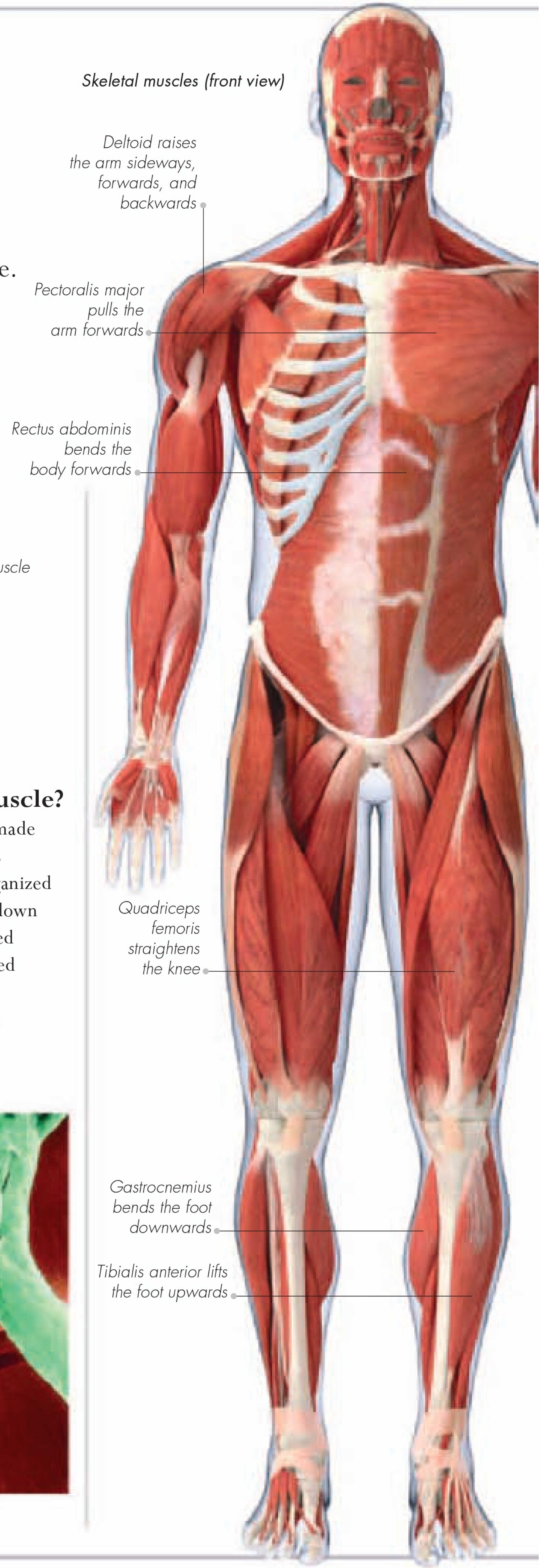
Q/A How do muscles work?

Skeletal muscle contracts when your brain tells it to. Signals are carried from the brain by neurons or nerve cells (green), the ends of which form junctions with muscle fibres (red). The arrival of a nerve signal makes filaments inside the myofibrils slide over each other so that their muscle fibres and, therefore, the muscle get shorter and "pull" on a part of your body so that you move.



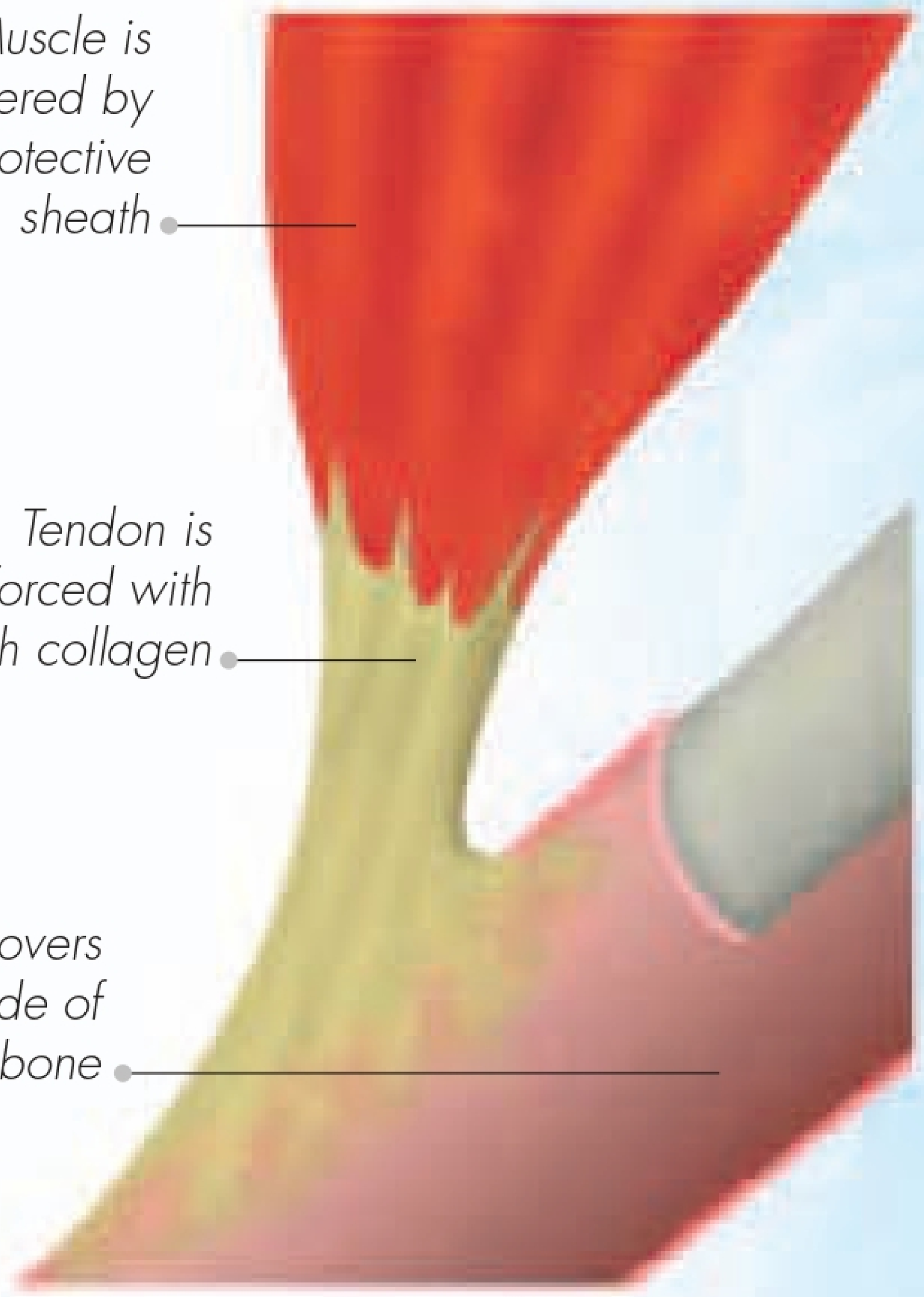
Nerve-muscle junction

Skeletal muscles (front view)



How are muscles attached to bones?

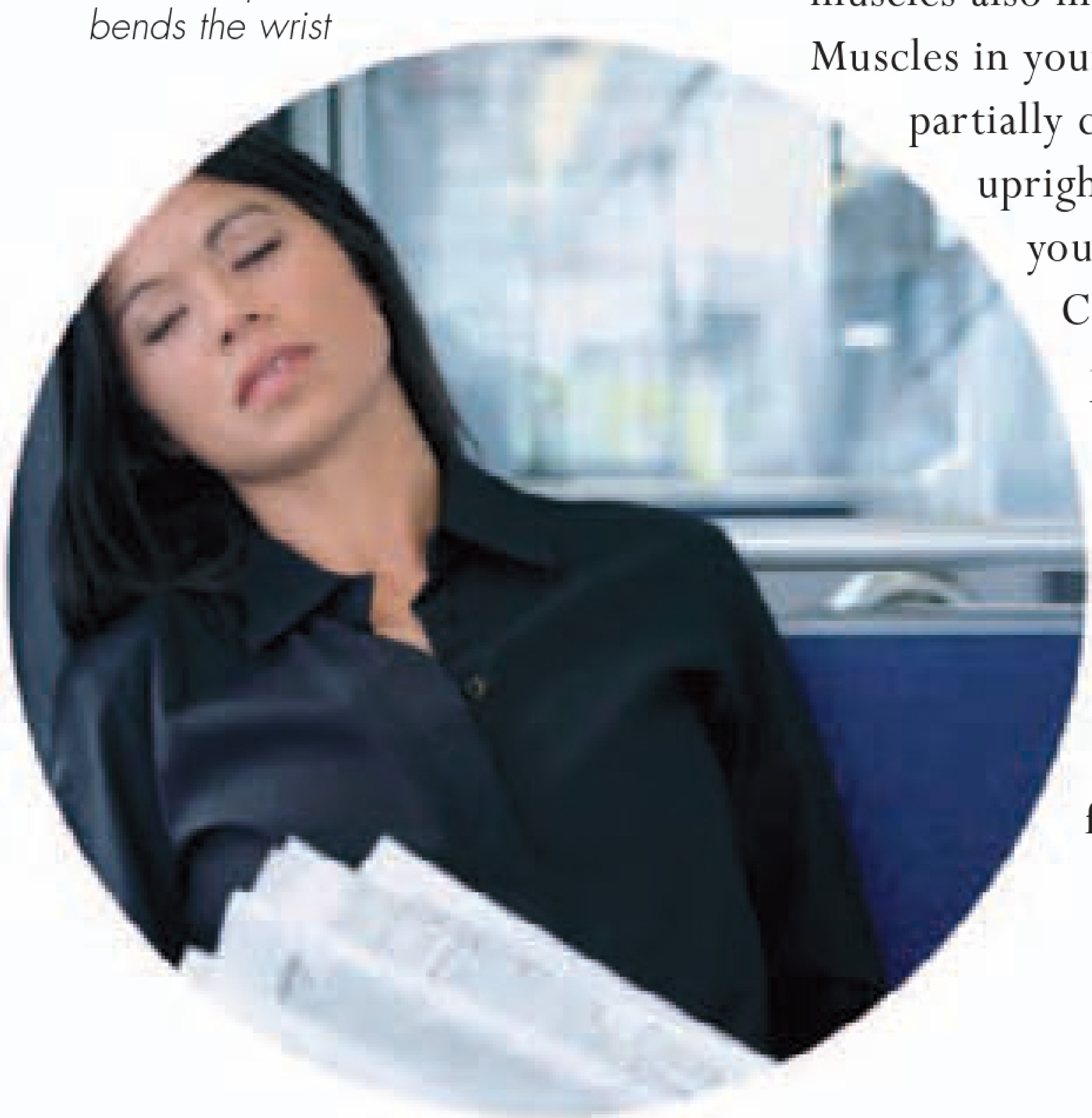
Q/A At each end of a muscle, a cord or sheet called a tendon fixes it firmly to a bone. Each tendon is reinforced with parallel bundles of tough collagen fibres. This makes it incredibly strong so that, when a muscle contracts to pull a bone, its tendon does not tear. A tendon extends from a muscle, through the periosteum, and into the bone's outer layer where it is firmly anchored.



Connecting muscle to bone

What happens when I sleep?

Q/A As well as moving your body, muscles also maintain your posture. Muscles in your neck, back, and hips partially contract to keep your body upright and head steady whether you are standing or sitting. Called muscle tone, this partial contraction is constantly adjusted by your brain. When you fall asleep, muscle tone almost disappears. That's why, if you happen to nod off in a chair, your head flops to the side.



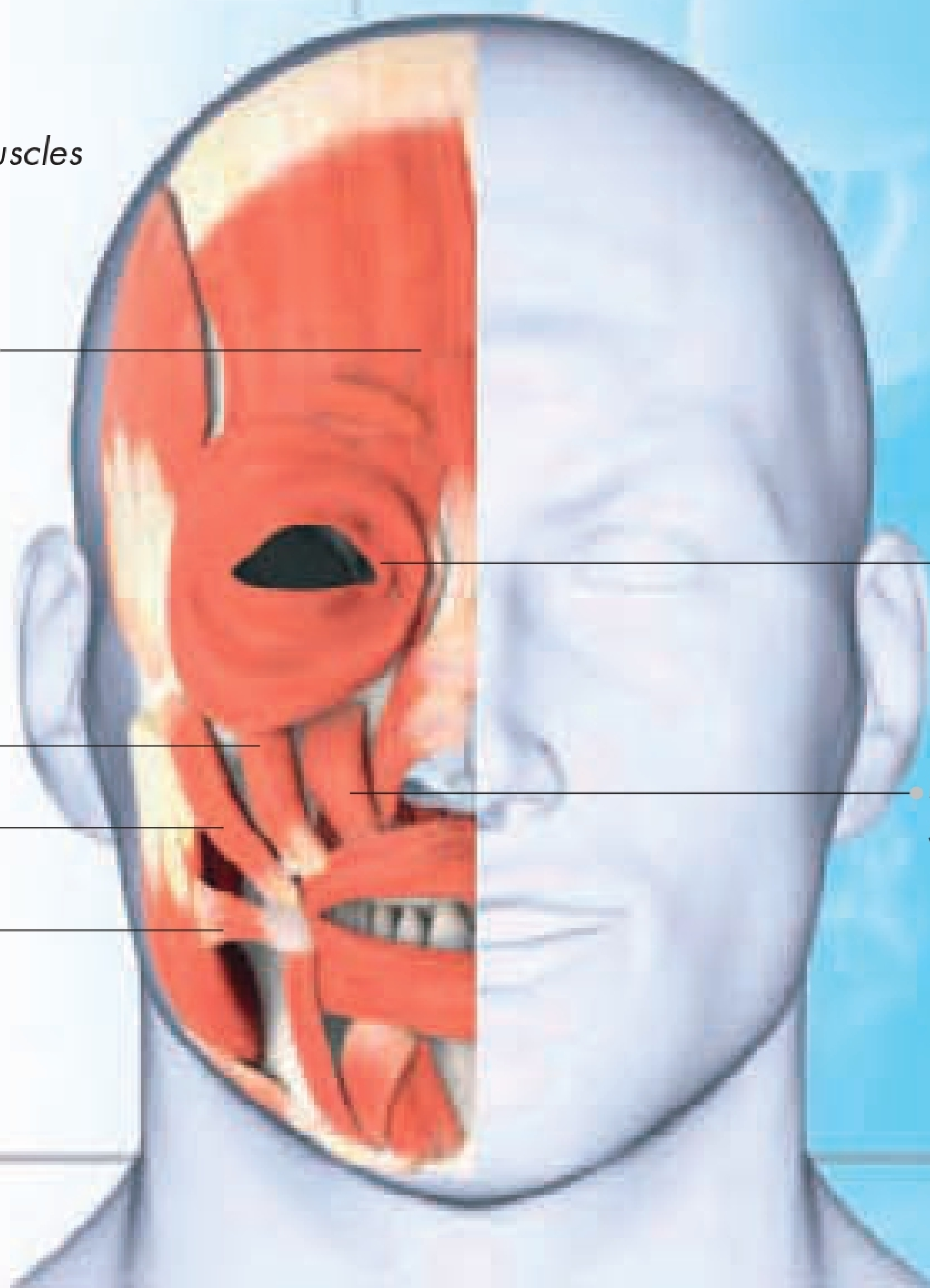
Falling asleep

More Facts

- You have more than 650 skeletal muscles that help to shape your body and make up to 40 per cent of your body weight.
- Your body's strongest muscle is the masseter, a jaw muscle which closes the mouth so that the teeth can crush food.
- Just 1.25 mm (0.05 in) long, the stapedius muscle inside the ear is the body's smallest skeletal muscle. It helps protect the ear from loud noises.
- The downward pull of gravity on Earth helps to strengthen muscles and bones. In space, where there is little gravity, they get weaker.

Astronaut space walking

Facial muscles

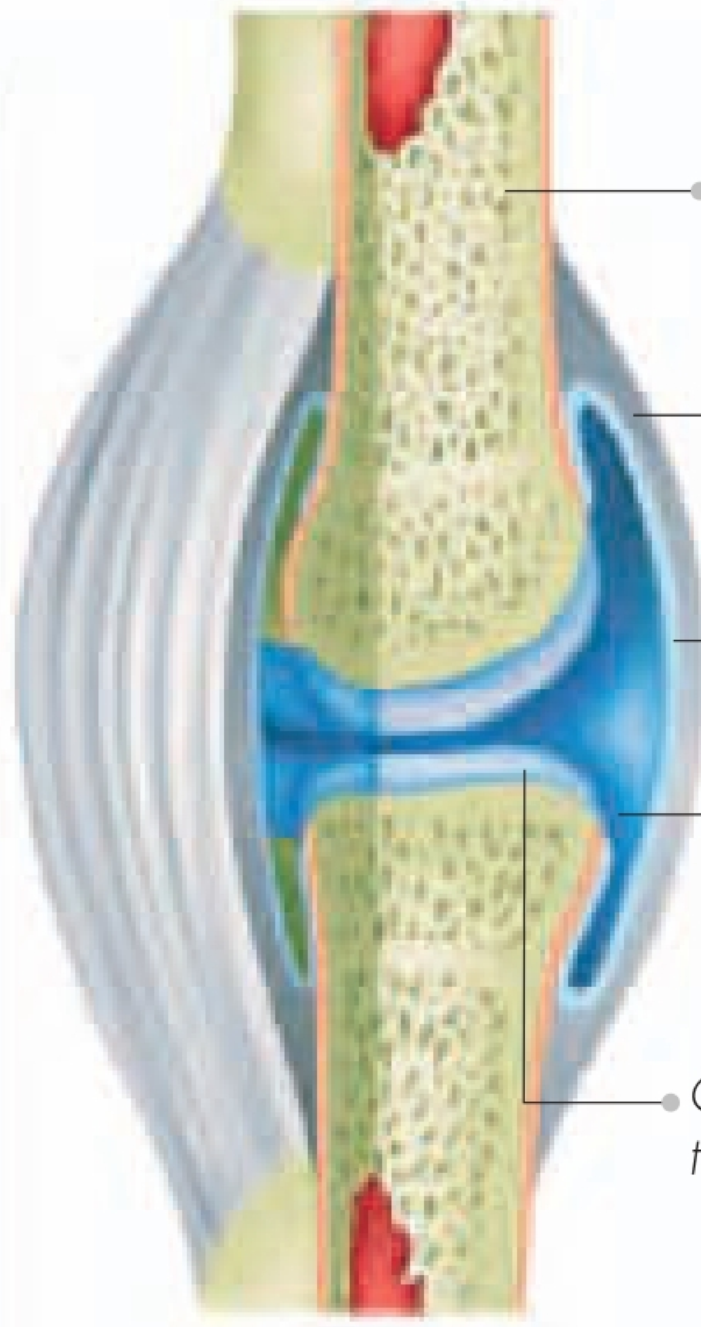


Which muscles make me smile?

Q/A You have about 30 small muscles that produce a vast range of facial expressions and reveal to others how you feel. One end of your facial muscles are attached to the skin of your face, which they tug to create a particular look, be it grinning or frowning. Smiling muscles include the risorius, the two zygomaticus muscles, which pull the corner of your mouth up and outwards, and the levator labii superioris, which raises your upper lip.

What makes athletes fast and flexible?

Anyone who exercises regularly and in the right way can improve their fitness, which is a measure of how efficiently their body works. Athletes are very good examples of how this can be done. The joints between their bones, which allow the body to move, are really flexible. The muscles that pull on those bones to create movement are very strong. Athletes also have great stamina because their heart works so efficiently to supply muscles with energy.



How do joints move smoothly?

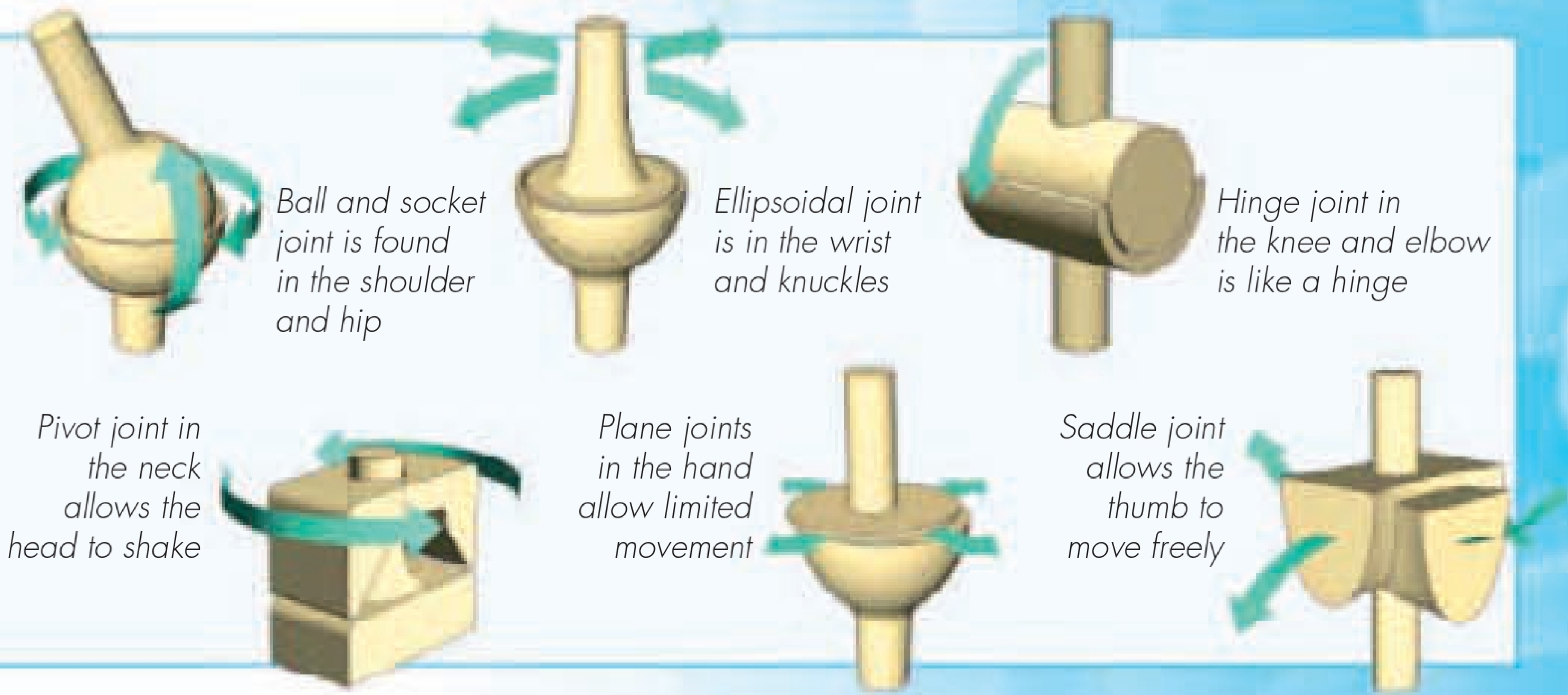
Q

A Most of your body's 400 joints are free-moving synovial joints. All share the basic structure you can see here. The ends of the bone are coated with slippery cartilage and are separated by oily synovial fluid, released by the synovial membrane. The combination of cartilage and fluid allows the joint to move smoothly, without the bone ends rubbing together.

Athlete in action

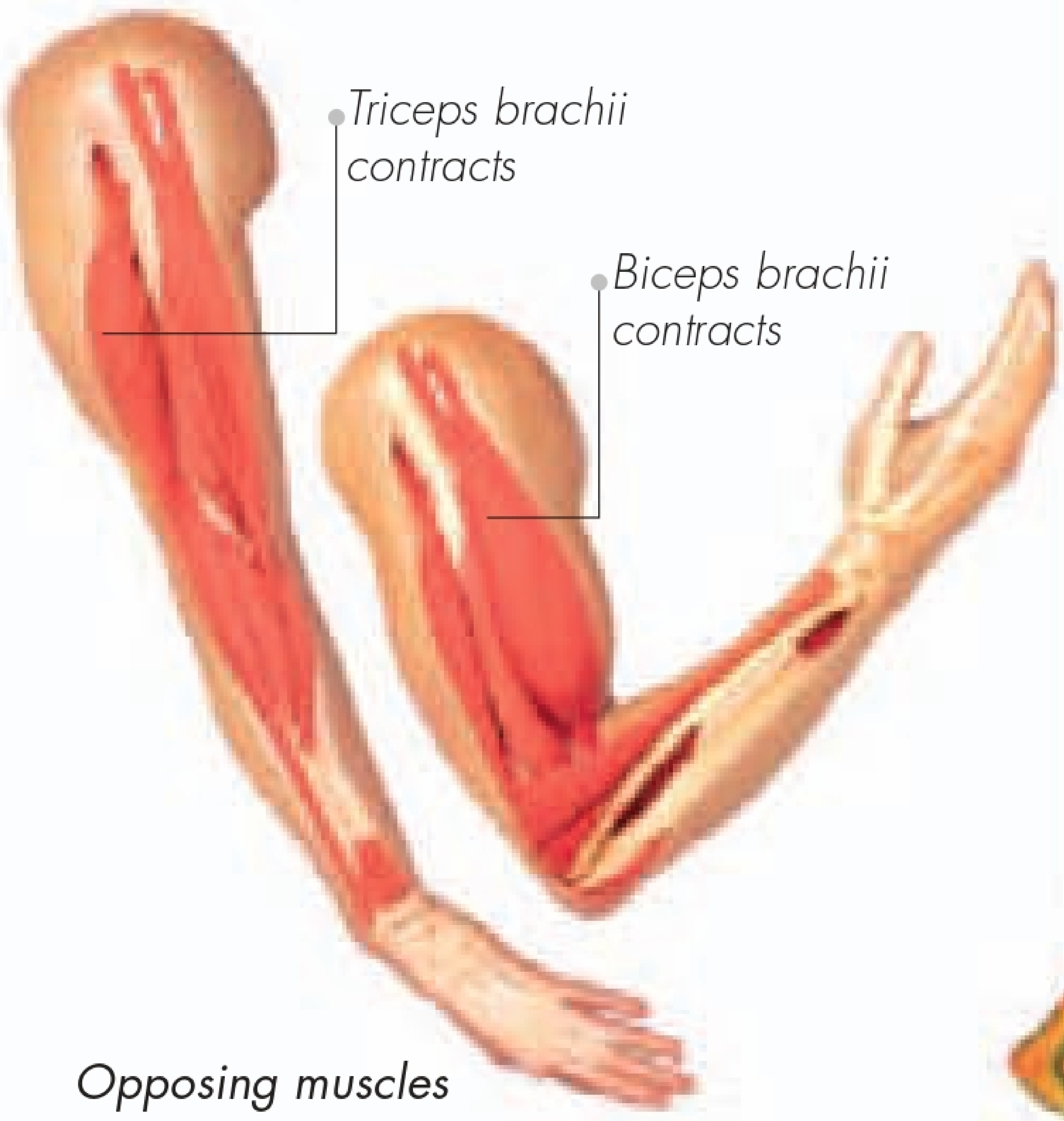
Are there different types of joints?

There are six different types of synovial joints in your body. The shapes of their bones' ends and how they fit together determines the range and freedom of movement each joint-type allows. The ball and socket joint, for example, allows all-round movement.



Q A How do muscles work with joints to move my body?

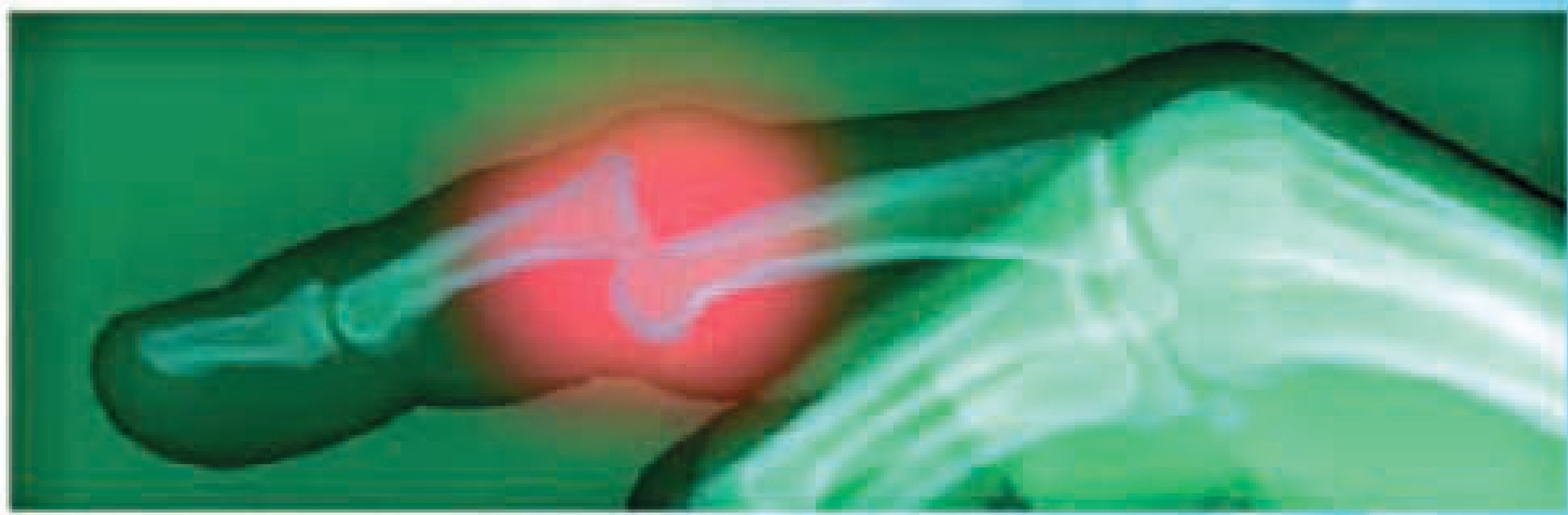
Muscles are attached to bones on either side of a joint. However, they can only pull not push, so opposing sets of muscles are needed to produce movements in different directions. In the arm, for example, the biceps brachii contracts to bend the elbow joint, while the triceps brachii contracts to straighten it.



Opposing muscles

Q A Why do I get hot when I exercise?

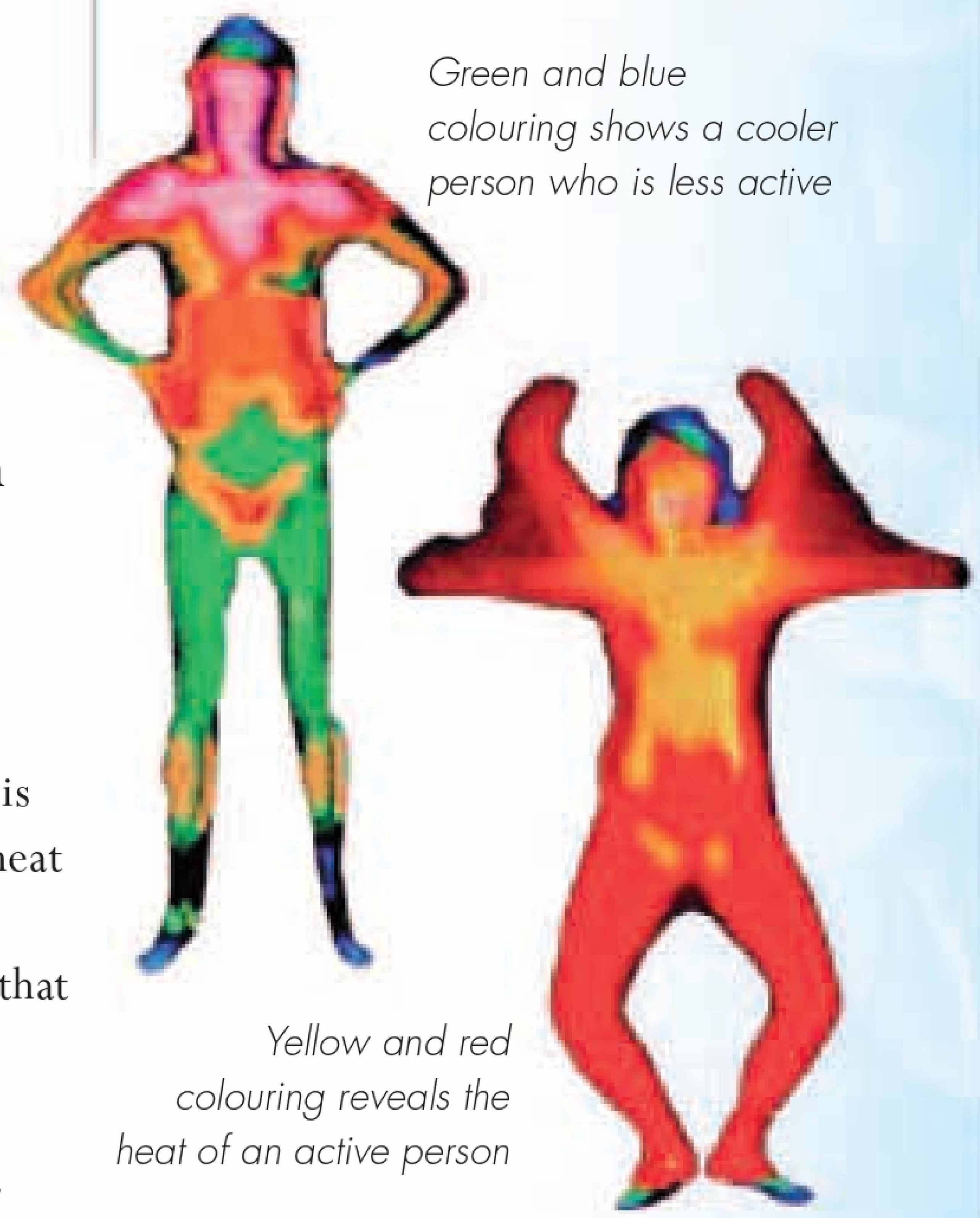
To move your body, muscles convert chemical energy, in the form of fuels such as glucose, into movement energy. A by-product of this conversion is heat. The more you exercise, the more heat your muscles release and the hotter you get. Thermography is a type of imaging that produces colour-coded "heat pictures" called thermograms, which show how much heat is being released by the body.



X-ray of a dislocated finger joint

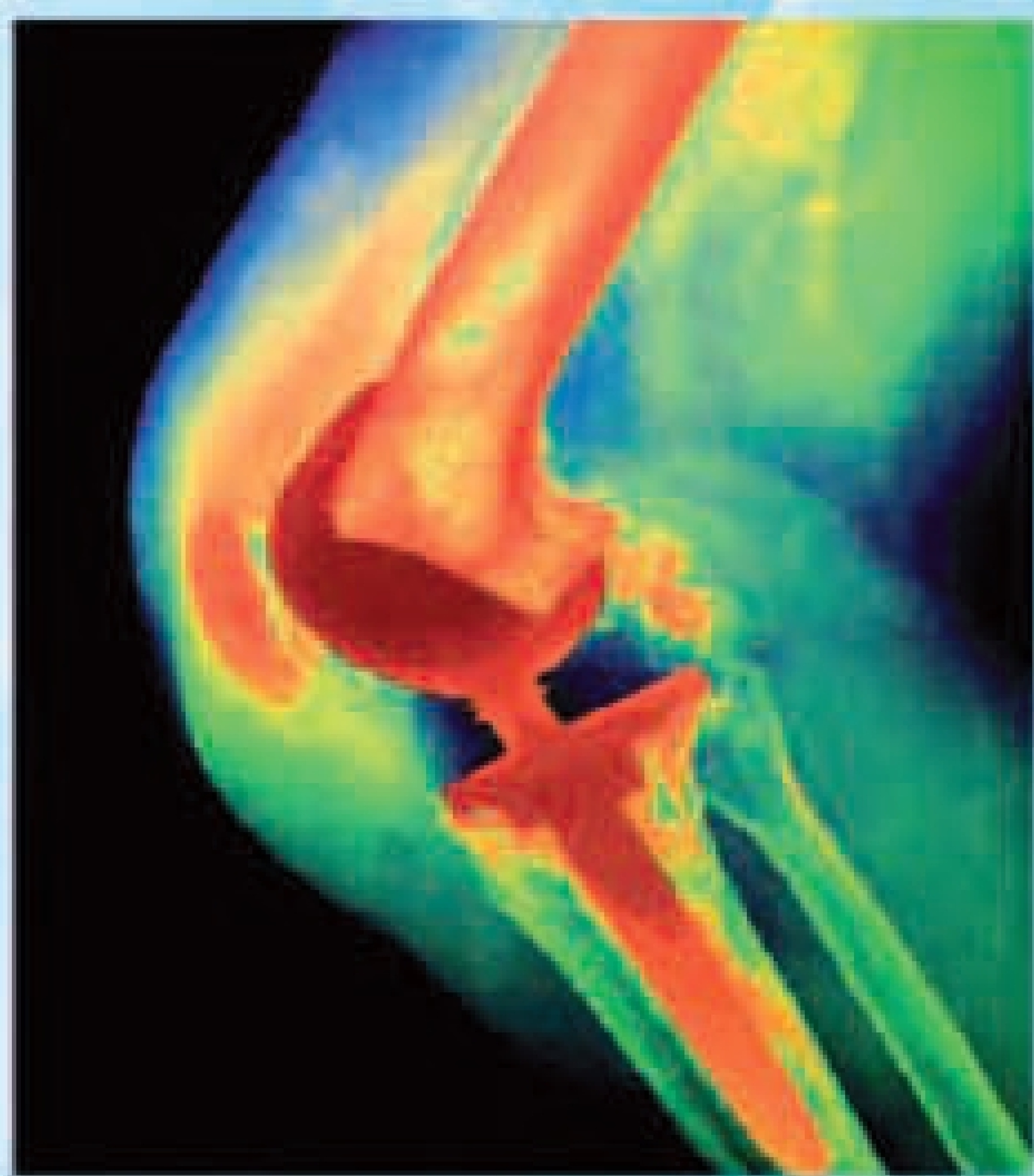
Q A What is a dislocated joint?

This X-ray shows two finger bones that have been forced out of line so that they no longer meet at a joint. In this situation the joint is said to be dislocated. Dislocated joints are often caused by sports injuries or falls. They are treated by a doctor who carefully moves the bones back into place.



Q A Do joints wear out?

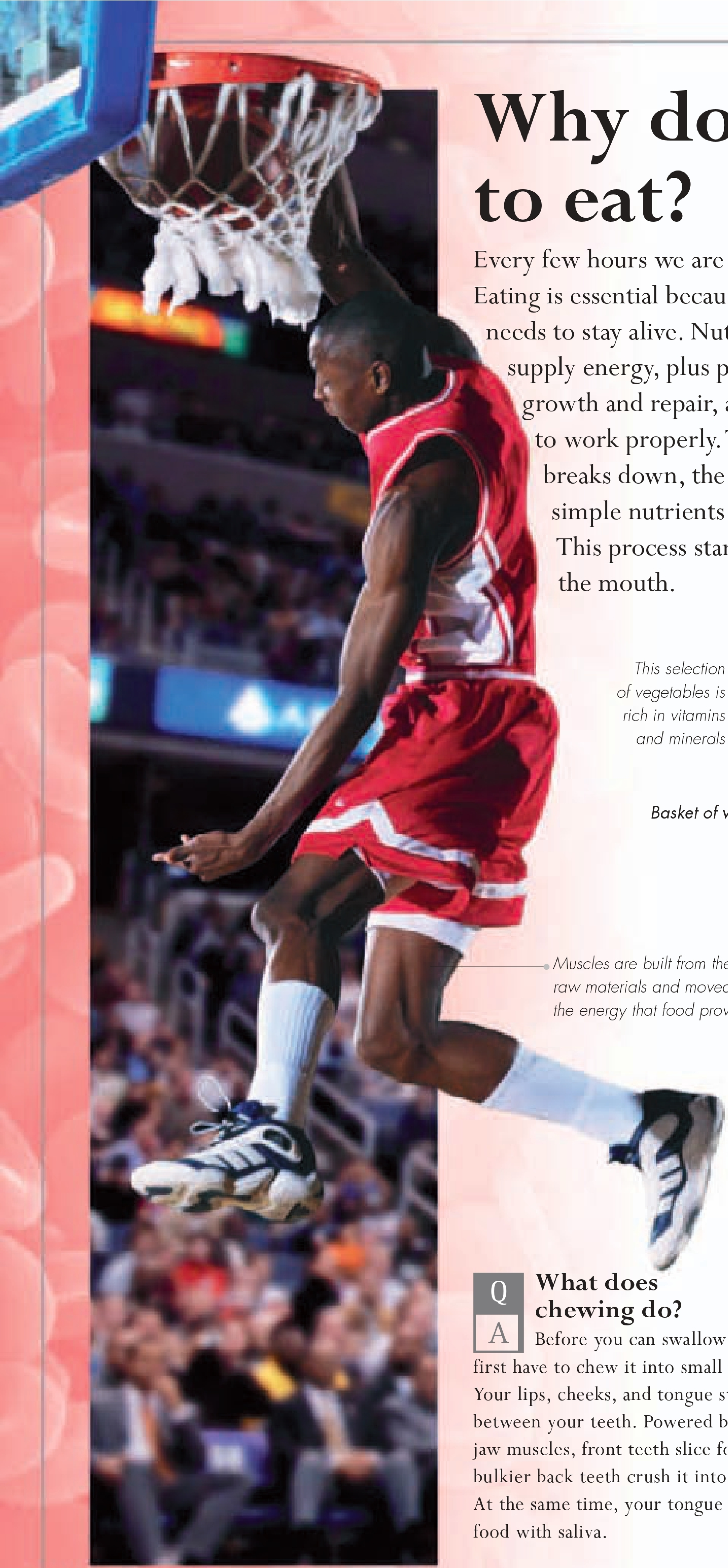
The cartilage that covers the ends of the bones in a joint can wear away with age. This makes the joint painful and much less flexible. One solution is to replace the worn-out joint with an artificial one. Joints that can be replaced in this way include those in the knee, hip, shoulder, and finger.



X-ray of an artificial knee joint

Fuelling the body

Why do I need to eat?



Every few hours we are driven by a feeling of hunger to eat food. Eating is essential because food contains nutrients that the body needs to stay alive. Nutrients include carbohydrates and fats, which supply energy, plus proteins, which provide the raw materials for growth and repair, and vitamins and minerals, which cells need to work properly. The body's digestive system digests, or breaks down, the complex molecules in food to release simple nutrients that the body can use. This process starts in the mouth.

This selection of vegetables is rich in vitamins and minerals

Basket of vegetables

Muscles are built from the raw materials and moved by the energy that food provides

Q Why should I eat vegetables?

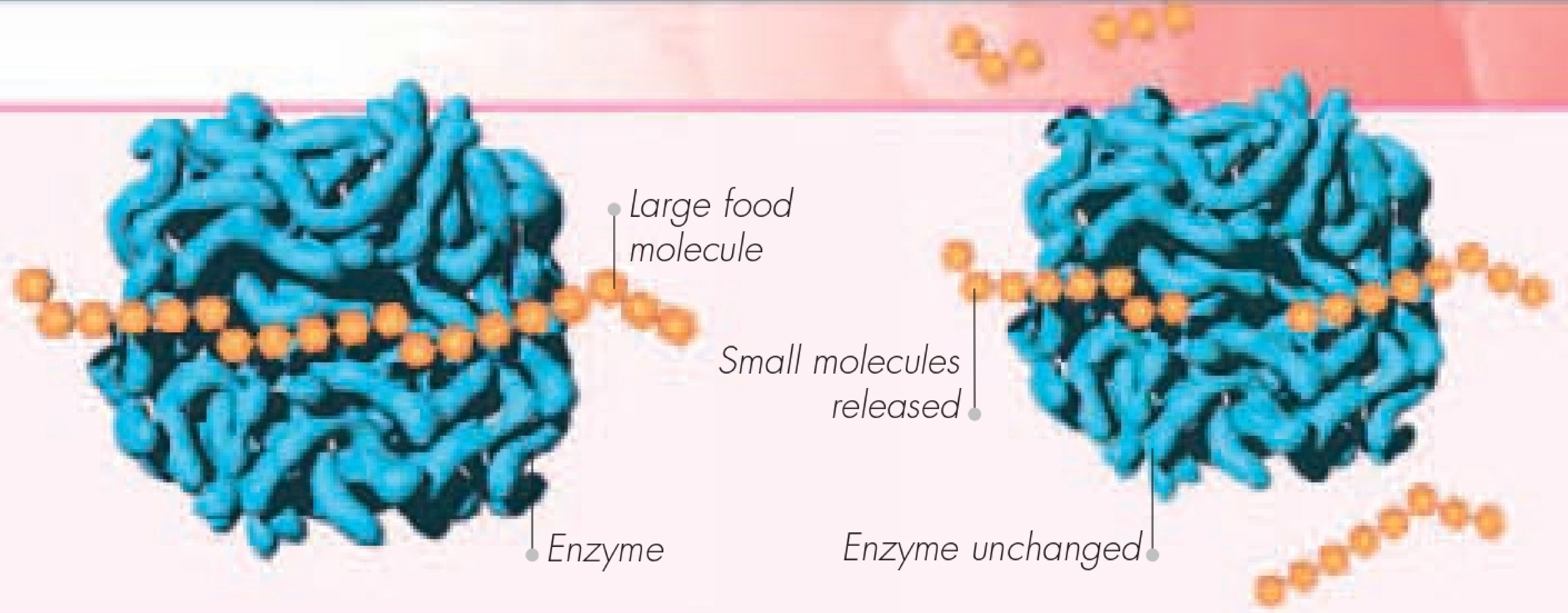
A To stay fit and healthy you need to eat a balanced diet. That is, what you eat day by day should contain the right amounts of nutrients to provide energy, building materials, and other essentials. Vegetables are a key part of a balanced diet because they provide carbohydrates and certain vitamins and minerals.

Q What does chewing do?

A Before you can swallow food you first have to chew it into small pieces. Your lips, cheeks, and tongue steer food between your teeth. Powered by strong jaw muscles, front teeth slice food, while bulkier back teeth crush it into a paste. At the same time, your tongue mixes food with saliva.

How is food broken down?

Your teeth and stomach use muscle action to break food into small particles. These particles are then targeted by chemical digesters called enzymes, especially in the small intestine. Enzymes speed up the breakdown of large food molecules into simple nutrients, such as glucose, that can be absorbed into the bloodstream.

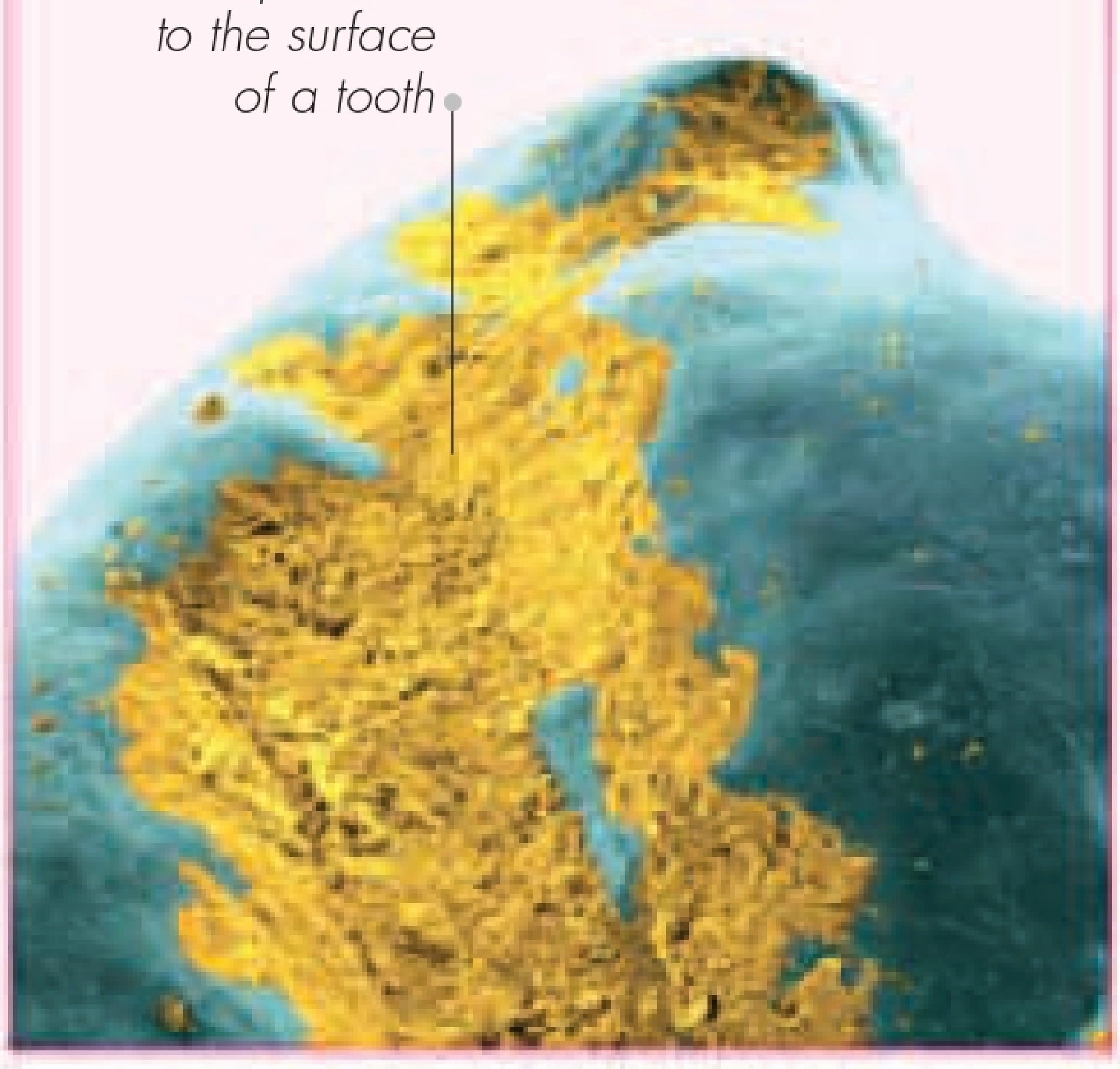


1 An enzyme attaches to a complex food molecule and locks it in place.

2 Enzyme helps to break the complex molecule into simpler nutrients.

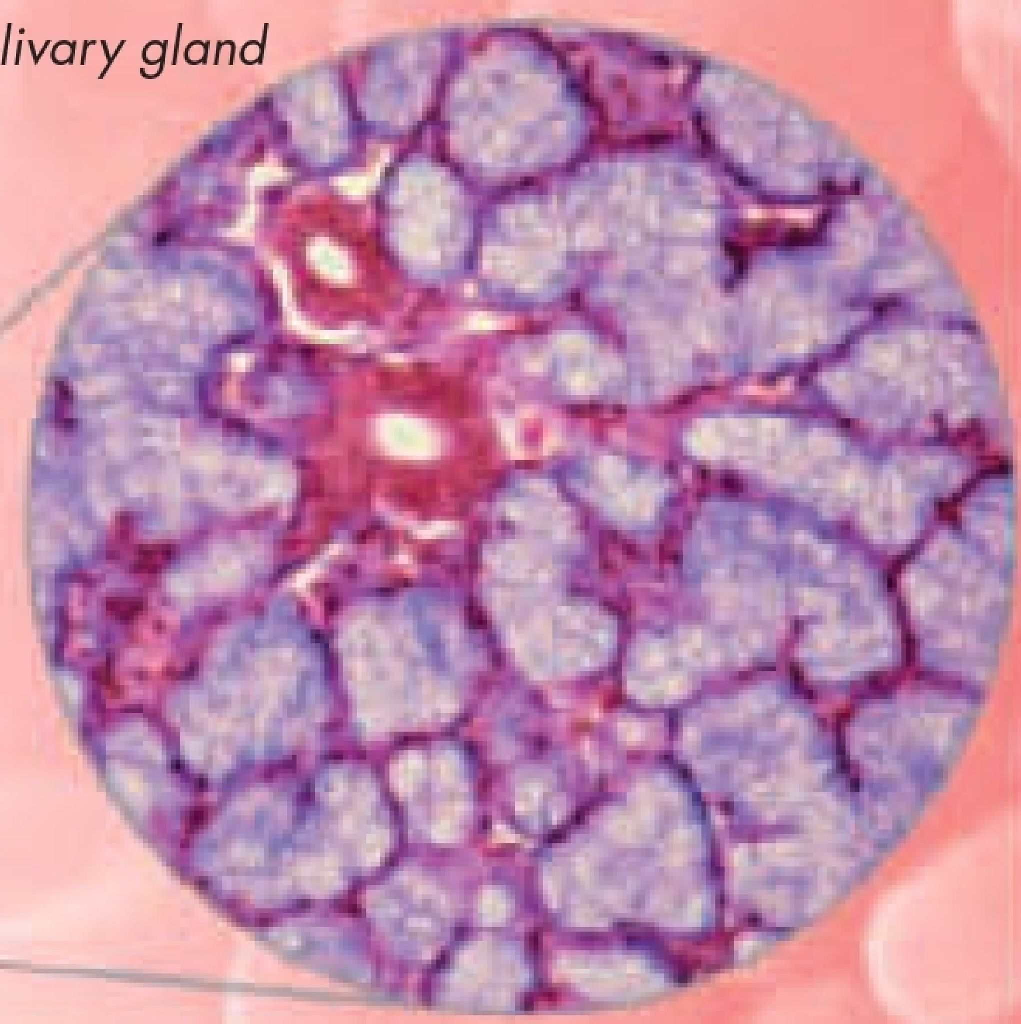
More Facts

- In an average lifetime a person will eat about 25 tonnes of food, equivalent to the combined weight of five African bull elephants.
- We have two sets of teeth during our lifetime. The first set contains 20 milk teeth. These are replaced gradually during childhood and teen years by 32 adult teeth.
- We release one litre (two pints) of saliva daily. Saliva also cleans the mouth and contains a bacteria-killing chemical called lysozyme.
- Plaque is a mixture of food and bacteria that builds up and sticks to teeth that are not brushed regularly. Plaque bacteria feed on food remains, releasing acids that eat away at the tooth and cause decay.



Tooth bacteria

Salivary gland

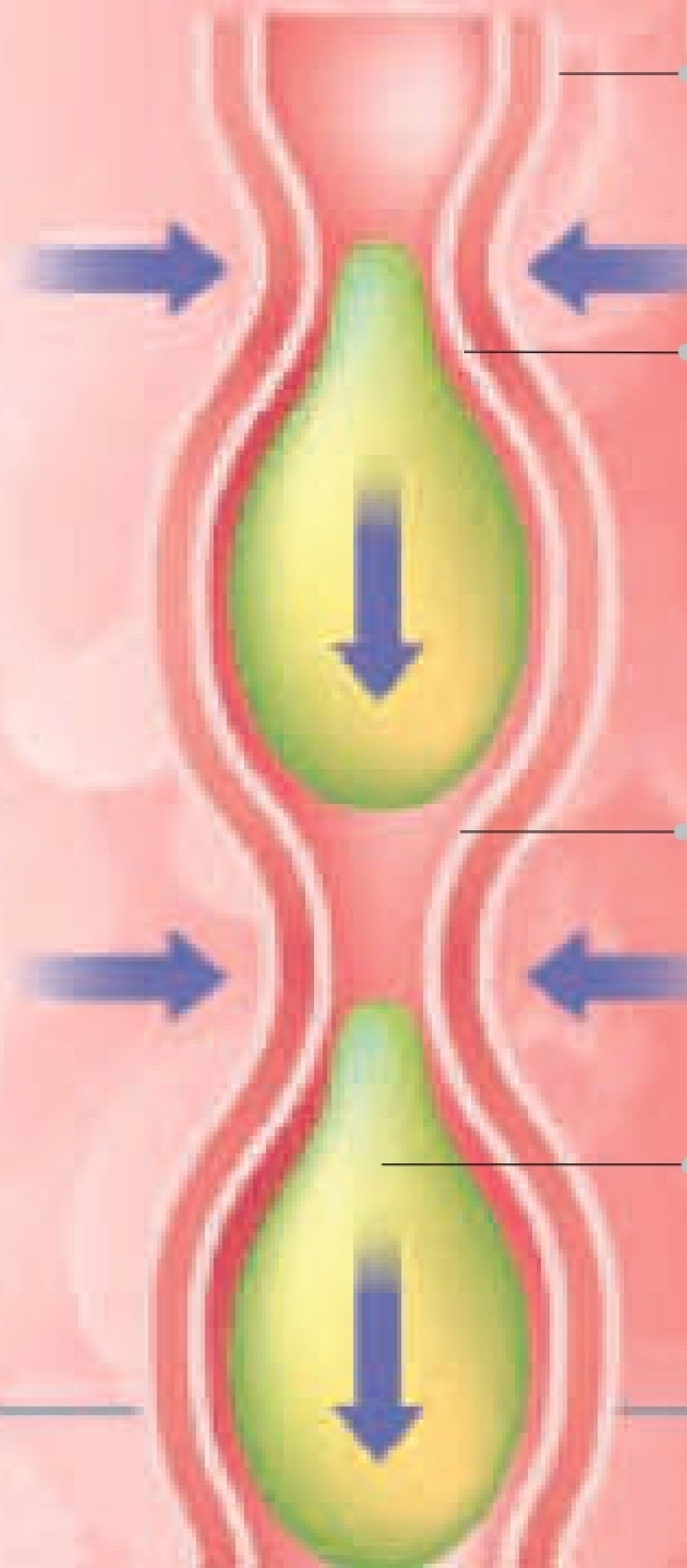


Q Why does my mouth water?

A If you are hungry, the sight, smell, or thought of food triggers the release of saliva. This watery liquid is squirted into your mouth by three pairs of salivary glands (left, yellow). Saliva moistens food during chewing. It also contains an enzyme that digests starchy food, and slimy mucus, which binds chewed food particles together and makes them easier to swallow.

Q What happens when I swallow?

A Once food has been thoroughly chewed, your tongue pushes it backwards. As soon as the slimy ball of food touches the back of your throat it sets off an automatic reflex reaction. You briefly stop breathing, to stop food going "down the wrong way", while food is pushed down your throat into the oesophagus. Muscles in the wall of your oesophagus alternately contract (squeeze) and relax to move food downwards to your stomach – a journey that takes just 10 seconds.



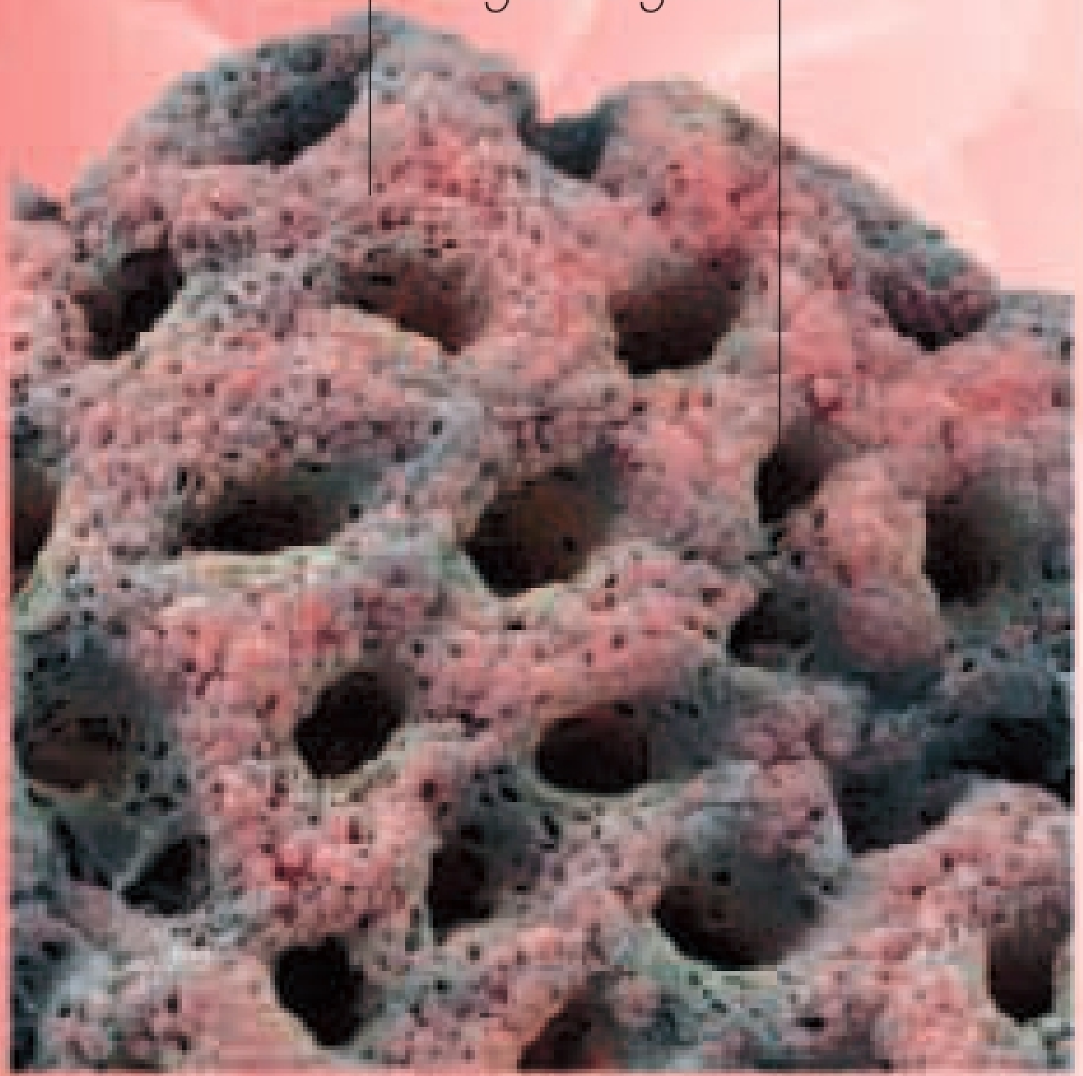
Food in the oesophagus

What makes me burp?

Digestion really gets started in your stomach. Here chewed-up lumps of food are turned into a soupy mixture – a process that may produce gases that make you burp. Digestion is completed in the small intestine, where complex food substances are broken down into simple nutrients, such as glucose. In the large intestine any leftover waste is turned into faeces, ready to be pushed out of the body.

Q What is stomach acid?

A Ten seconds after being swallowed, food arrives in the stomach where it is mixed with gastric (stomach) juice. This highly acidic liquid is produced by millions of gastric glands deep in the stomach's lining. As well as a strong acid, gastric juice contains a protein-digesting enzyme called pepsin that only works in acidic conditions. Stomach acid also kills most harmful bacteria in food and drink.

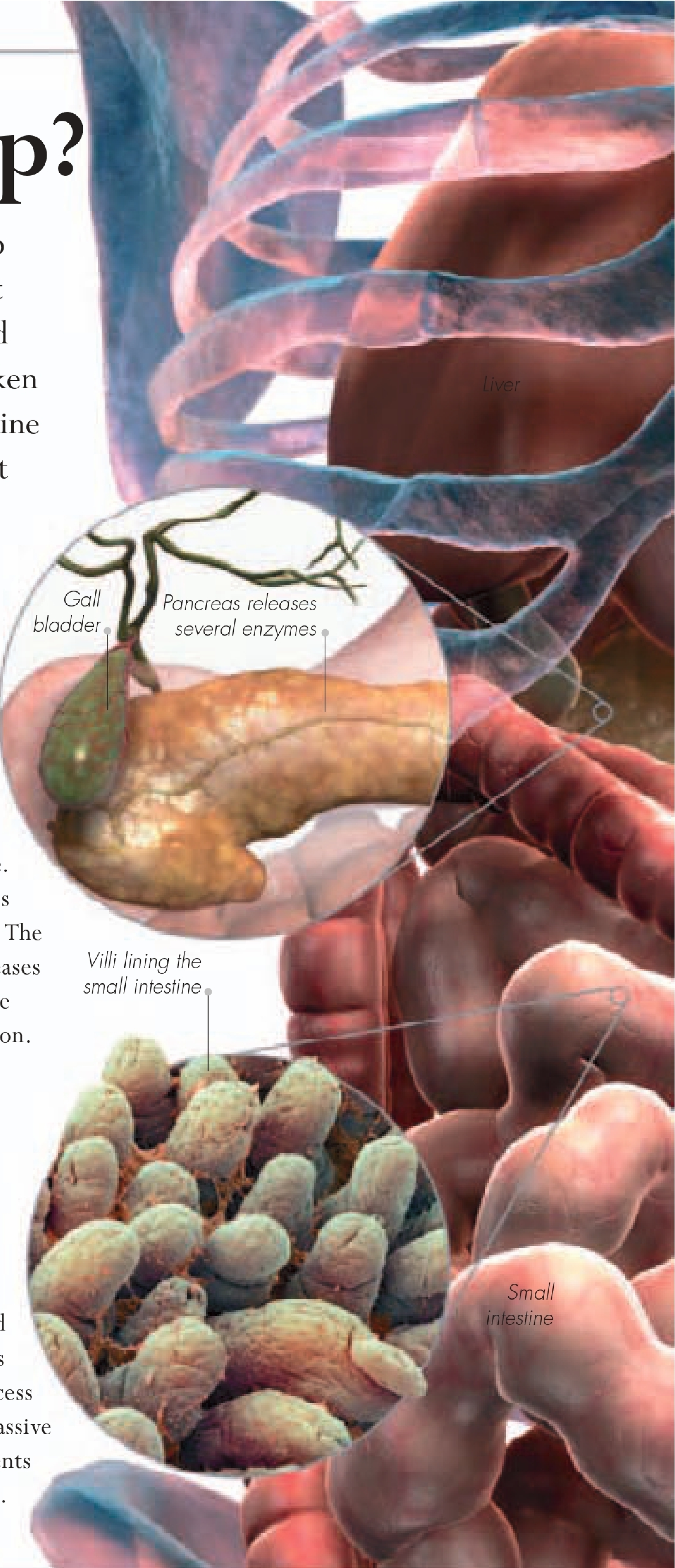


Q What's the point of a pancreas?

A Tucked under the stomach, your pancreas plays a key part in digestion. It releases pancreatic juice through a duct (tube) into the duodenum, the first part of the small intestine. This juice contains several enzymes that digest different types of food. The nearby gall bladder stores and releases bile, made by the liver, through the same duct, and this aids fat digestion.

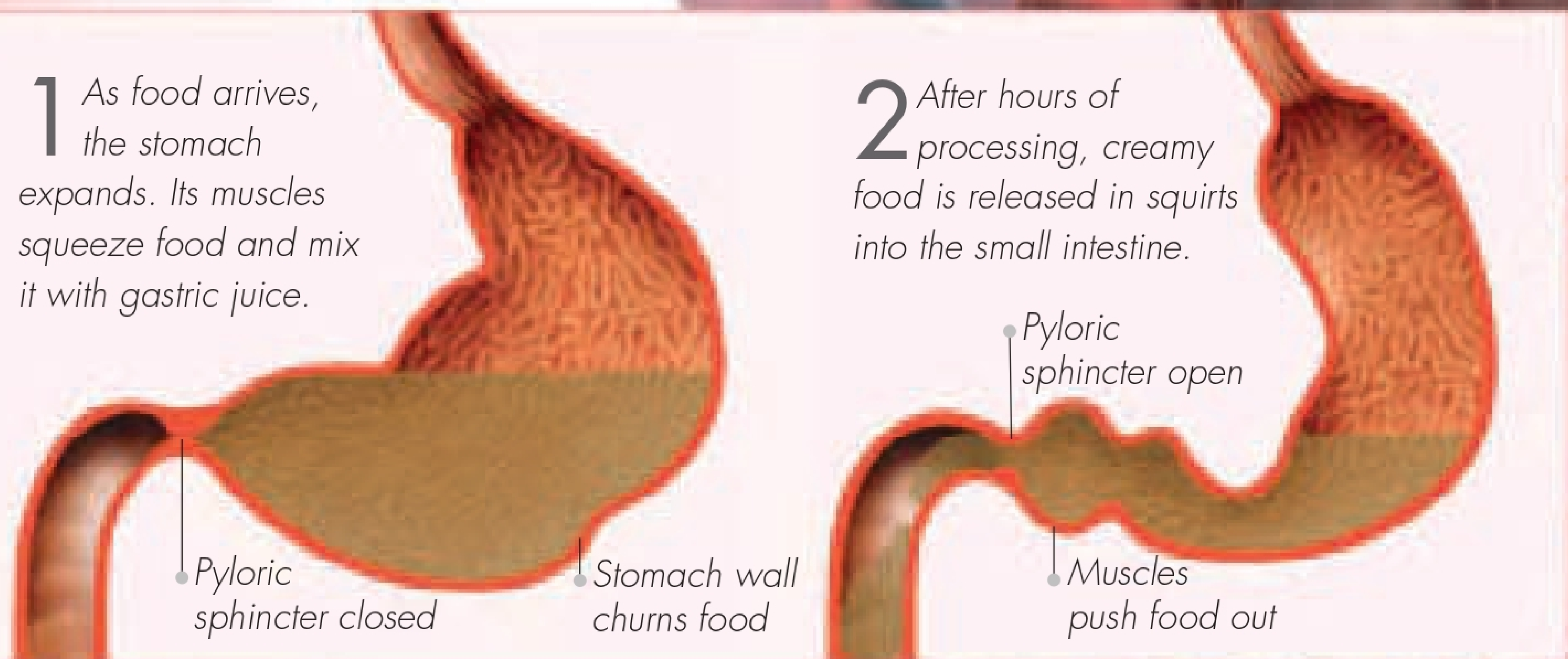
Q How big is the small intestine?

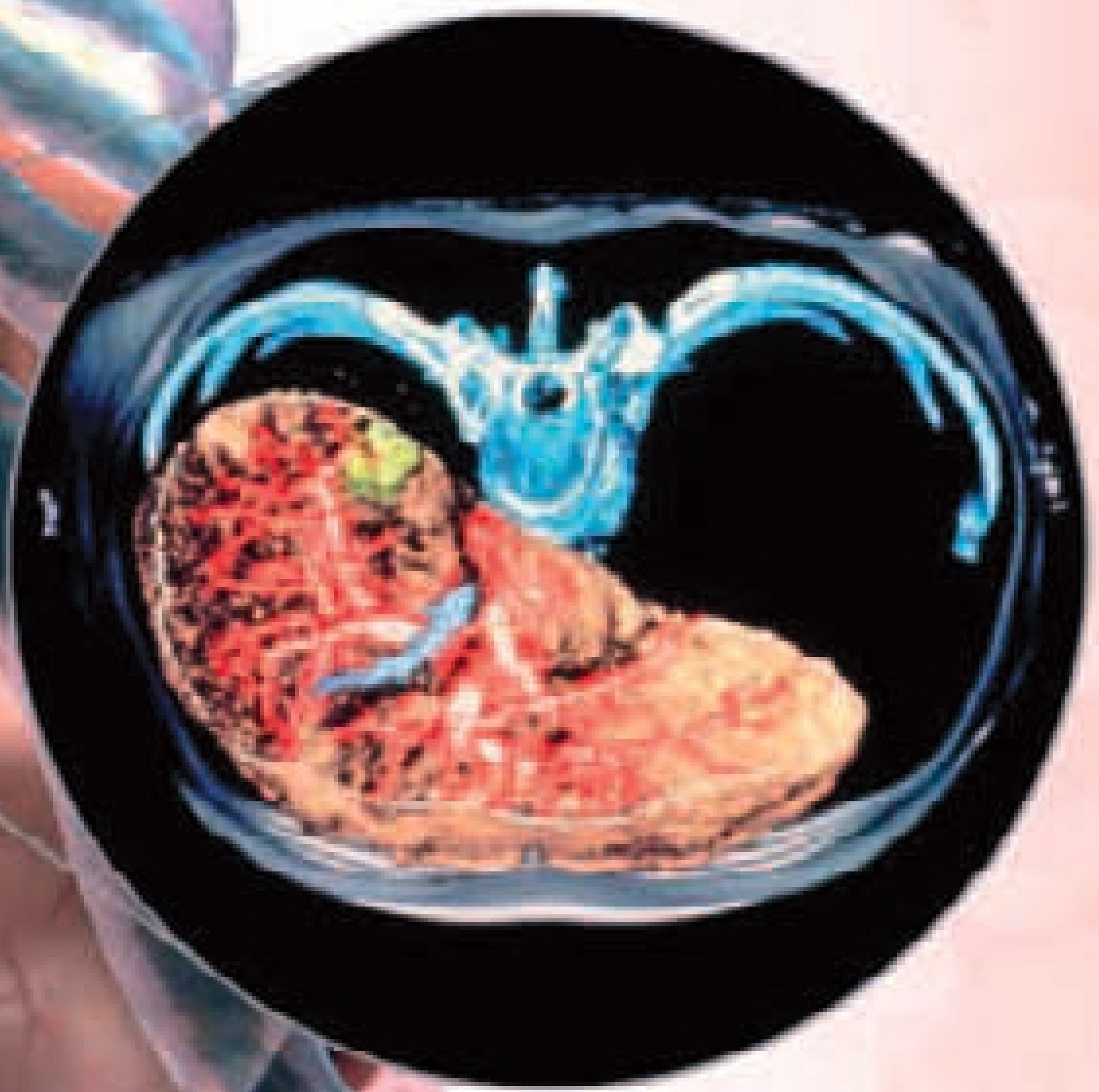
A The most important part of the digestive system, the small intestine is narrower but much longer than the large intestine. Its inner surface is folded and covered with tiny finger-like villi. Enzymes on their surface complete the process of digestion, and villi provide a massive surface across which simple nutrients are absorbed into the bloodstream.



How does the stomach work?

When food arrives in the stomach, its lower end – the exit into the small intestine – is closed off by a ring of muscle called the pyloric sphincter. The stomach's muscular walls mix food with gastric juice and churn it into a creamy paste. After three or four hours of mixing, part-digested food is released in small amounts into the small intestine.





CT scan shows section through a liver

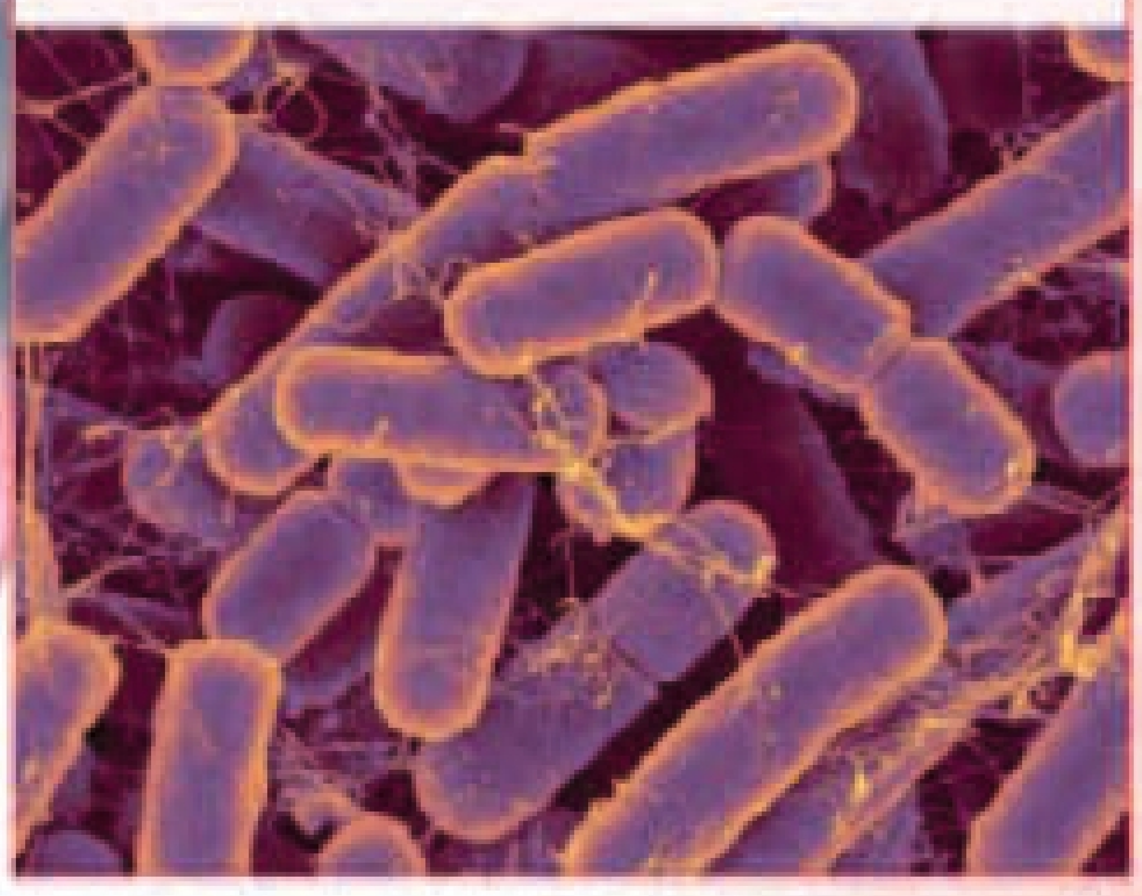
Q A Could I live without a liver?

Your liver is essential for life. Its busy cells perform more than 500 jobs that balance the chemical make-up of your blood. Those jobs include storing and processing recently digested nutrients – such as glucose, fats, vitamins, and minerals – arriving from the small intestine, removing poisons from the blood, and recycling worn-out red blood cells. These activities also release heat that helps keep your body's insides warm.

More Facts

- The pancreas releases two hormones, insulin and glucagon, into the bloodstream. These chemical messengers control levels of glucose – the body's main energy supply – in the blood.
- The liver is your body's largest internal organ. Only your skin is bigger and heavier.
- The small intestine is about 6 m (20 ft) long and 2.5 cm (1 in) wide. The large intestine is about 1.5 m (5 ft) long and 5 cm (2 in) wide.
- Billions of bacteria live harmlessly inside the colon, the longest part of the large intestine. They feed on undigested waste, give faeces (poo) their colour and smell, and make farts.

Bacteria inside the colon



Video pill

Q A How long does digestion take?

The whole digestive process, from food being chewed to waste emerging from the other end, takes between one and two days. A device called a video pill takes a similar time, once swallowed, to travel from mouth to anus. It contains a tiny camera, a light source, and a transmitter that sends images of the inside of the intestines to a receiver outside a patient's body. Doctors then look at the images to see if the patient has any problems.

Why can't I breathe underwater?

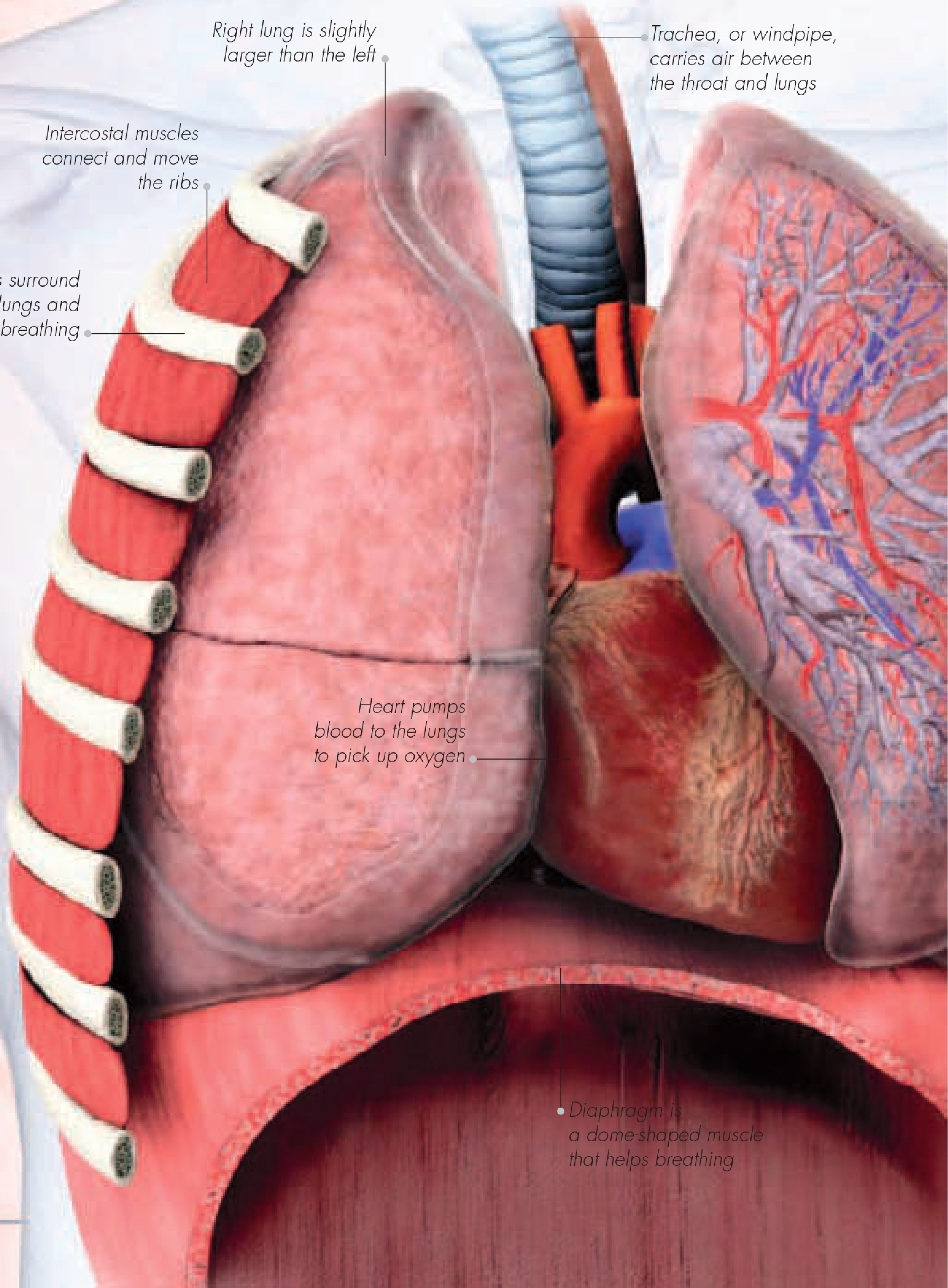
Every time you breathe in, air is carried by airways to the lungs. Here, oxygen from the air enters the bloodstream to be carried to all body cells. They need constant supplies of oxygen to release the energy that keeps them and you alive. That process also releases waste carbon dioxide, which you breathe out. Your lungs only work in air – to breathe underwater you would need gills, like a fish.

Q Is it windy inside the windpipe?

A As you breathe in and out, air rushes up and down your trachea, or windpipe, so it is quite breezy in there. At its lower end the trachea splits into two bronchi, one for each lung. Each bronchus then divides into smaller and smaller branches inside the lungs, getting air to every part.

Q What goes on inside the lungs?

A The smallest branches of the bronchi, called bronchioles, end in bunches of tiny air sacs. There are 150 million of these microscopic air sacs, called alveoli, in each lung. Oxygen passes from the alveoli into the bloodstream to be carried to all the body's cells, while carbon dioxide moves in the opposite direction.

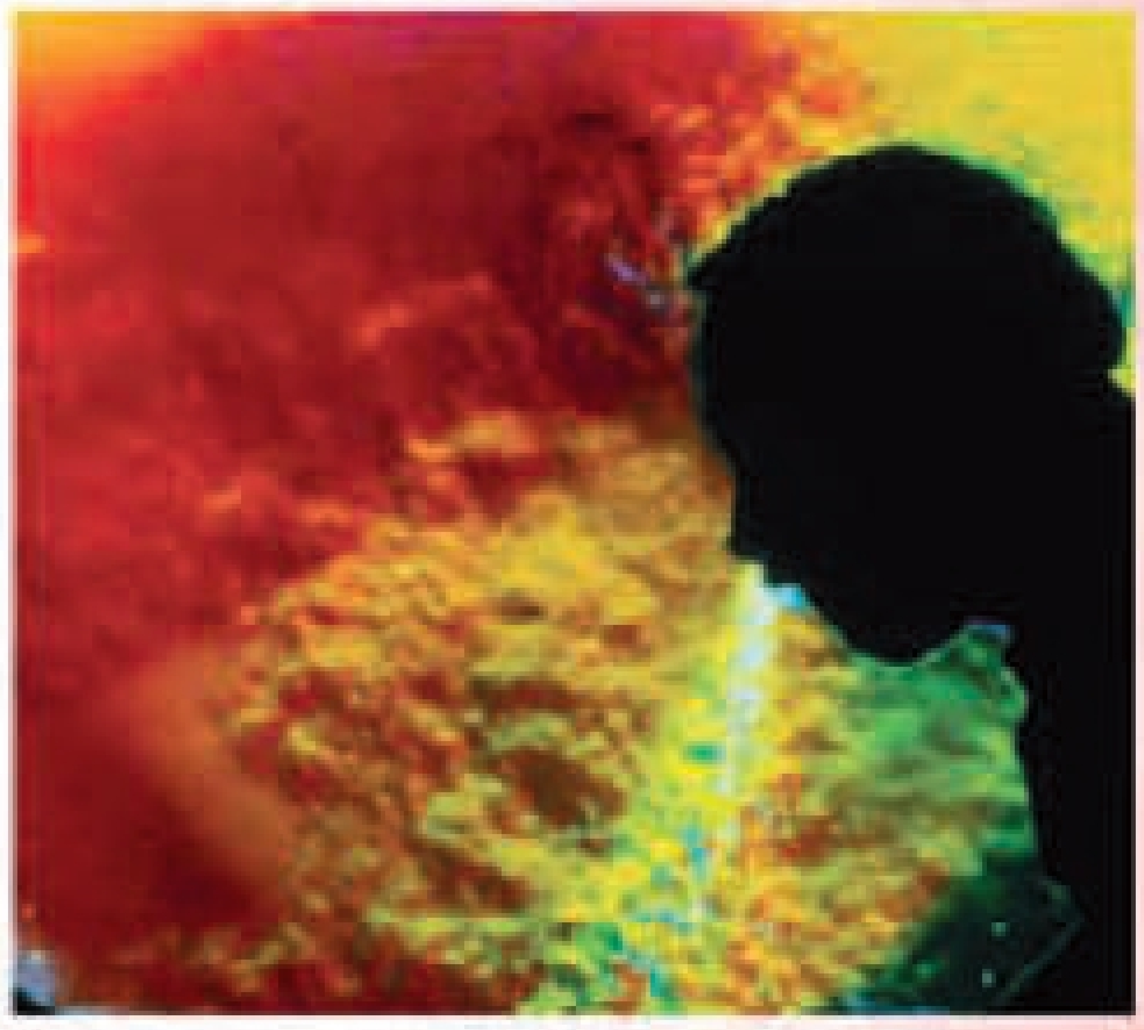


Lungs

Alveoli

Should I breathe through my nose?

It is preferable to inhale through your nose rather than your mouth. Air passing through the nasal cavity – the space behind your nose – is automatically cleaned, moistened, and warmed. Sticky mucus and hair-like cilia lining the nasal cavity trap and dispose of dust and other particles that might otherwise damage your lungs.



Air turbulence caused by a sneeze

What causes hay fever?

We all inhale particles, such as pollen grains, when we breathe in. Some people react to these particles and develop an allergy called hay fever. This results in watery eyes, a runny, itchy nose, and sneezing. When somebody sneezes a surge of air, released suddenly from the lungs, blasts through the nasal cavity to remove any irritation.

Cilia lining the nasal cavity

Musician blows into a trumpet

Branching bronchi carry air to all parts of the left lung

How do musicians play and breathe at the same time?

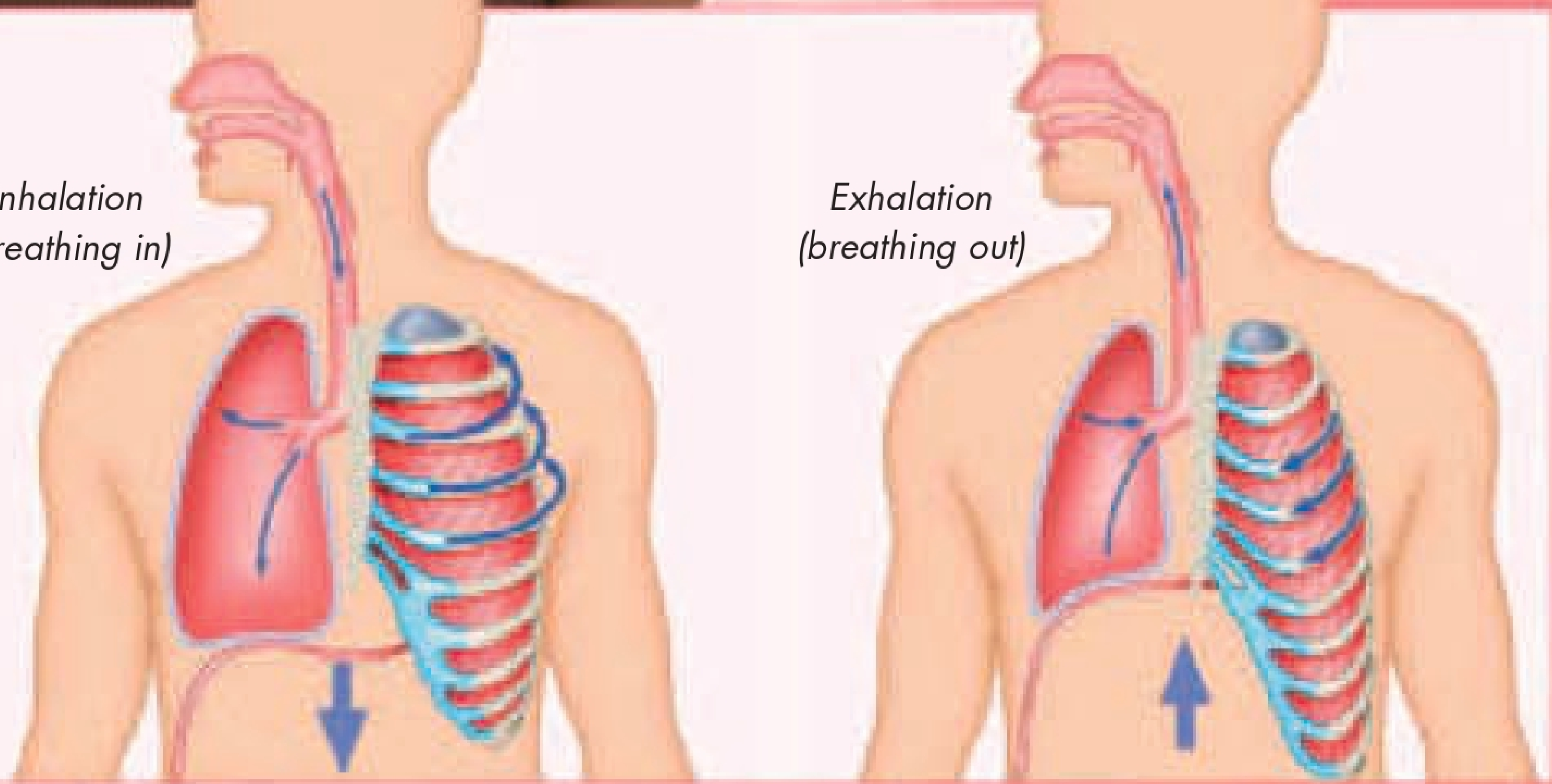
Some musicians who play wind instruments, such as the trumpet or oboe, are able to use a technique called circular breathing. This allows them to play music without interruption for longer periods of time than they could do with normal breathing. They learn to use their cheeks like bellows to maintain a flow of air through the instrument while at the same time inhaling air through their nose.

Why does my chest move when I breathe?

Your lungs cannot expand and shrink of their own accord. When you inhale, your diaphragm flattens and pushes downwards while your ribs and chest move upwards and outwards. This makes your lungs expand so that air is sucked in. During exhalation the diaphragm is pushed upwards, the ribs move downwards, your chest and lungs get smaller, and air is pushed out.

Inhalation (breathing in)

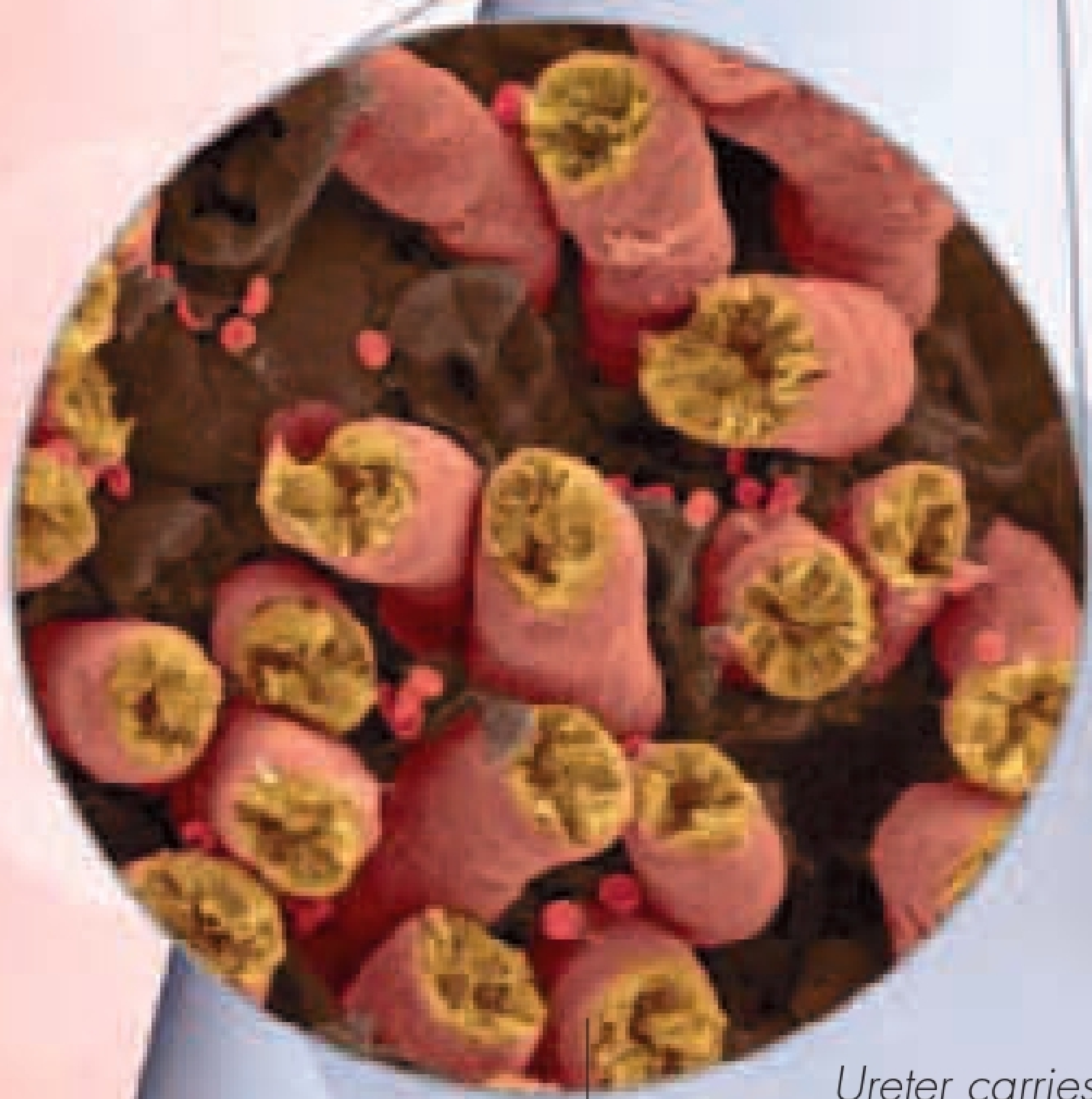
Exhalation (breathing out)



What is wee?

Your body's built-in waste disposal service, the urinary system, consists of two kidneys, two ureters, a bladder, and a urethra. The kidneys constantly process blood to keep its composition the same. They remove poisonous wastes produced by cells and surplus water from food and drink. Mixed together, the wastes and water form urine that is released from your body when you wee.

Urinary system



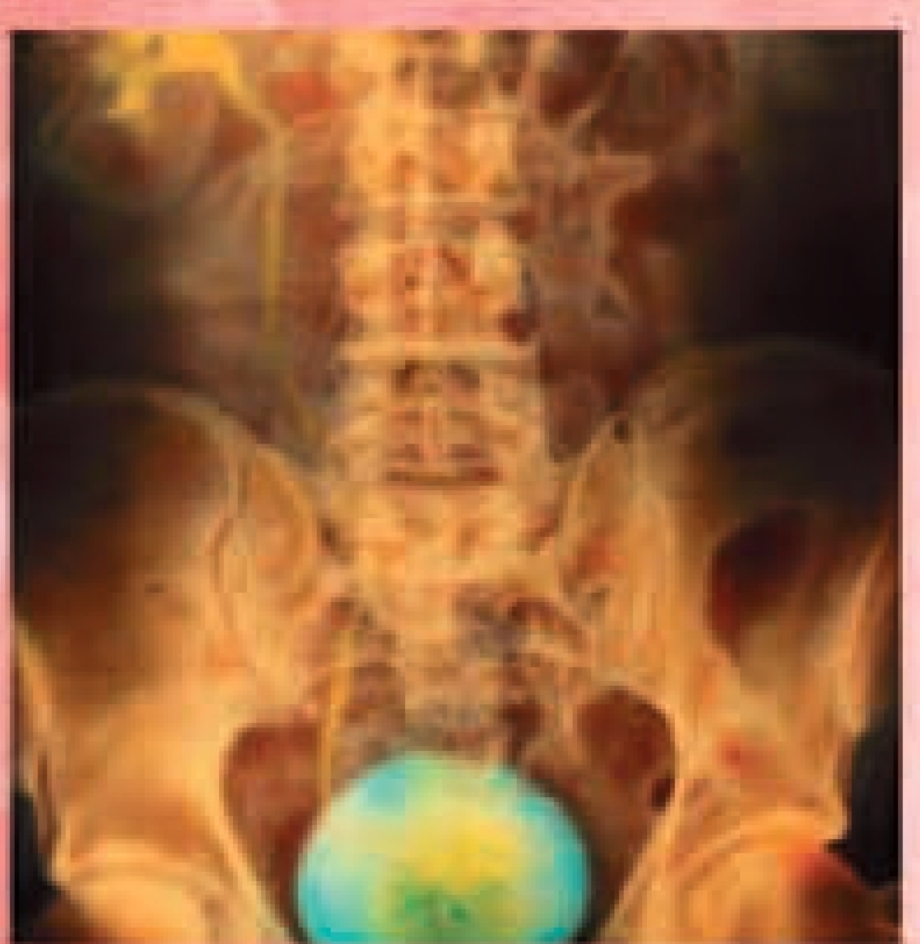
How is urine made?

Q/A Inside each kidney there are a million tiny, coiled tubes called nephrons. At one end of the nephron, fluid is filtered from the blood. As this fluid passes along the nephron, useful substances such as glucose pass back into the bloodstream. The remaining waste liquid, now called urine, flows out of the kidney and down the ureter to the bladder where it is stored.

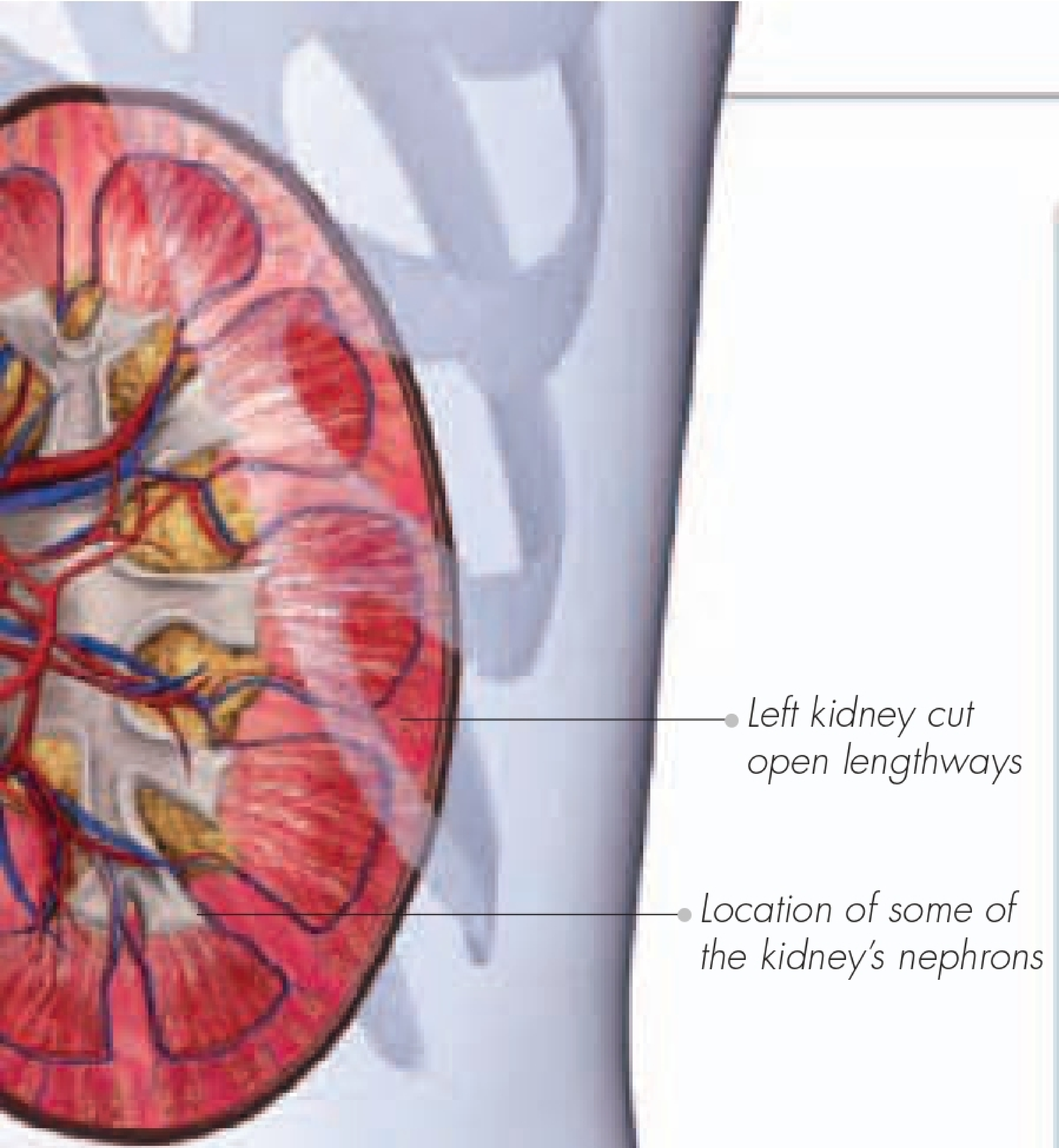
What makes us feel the need to go to the loo?

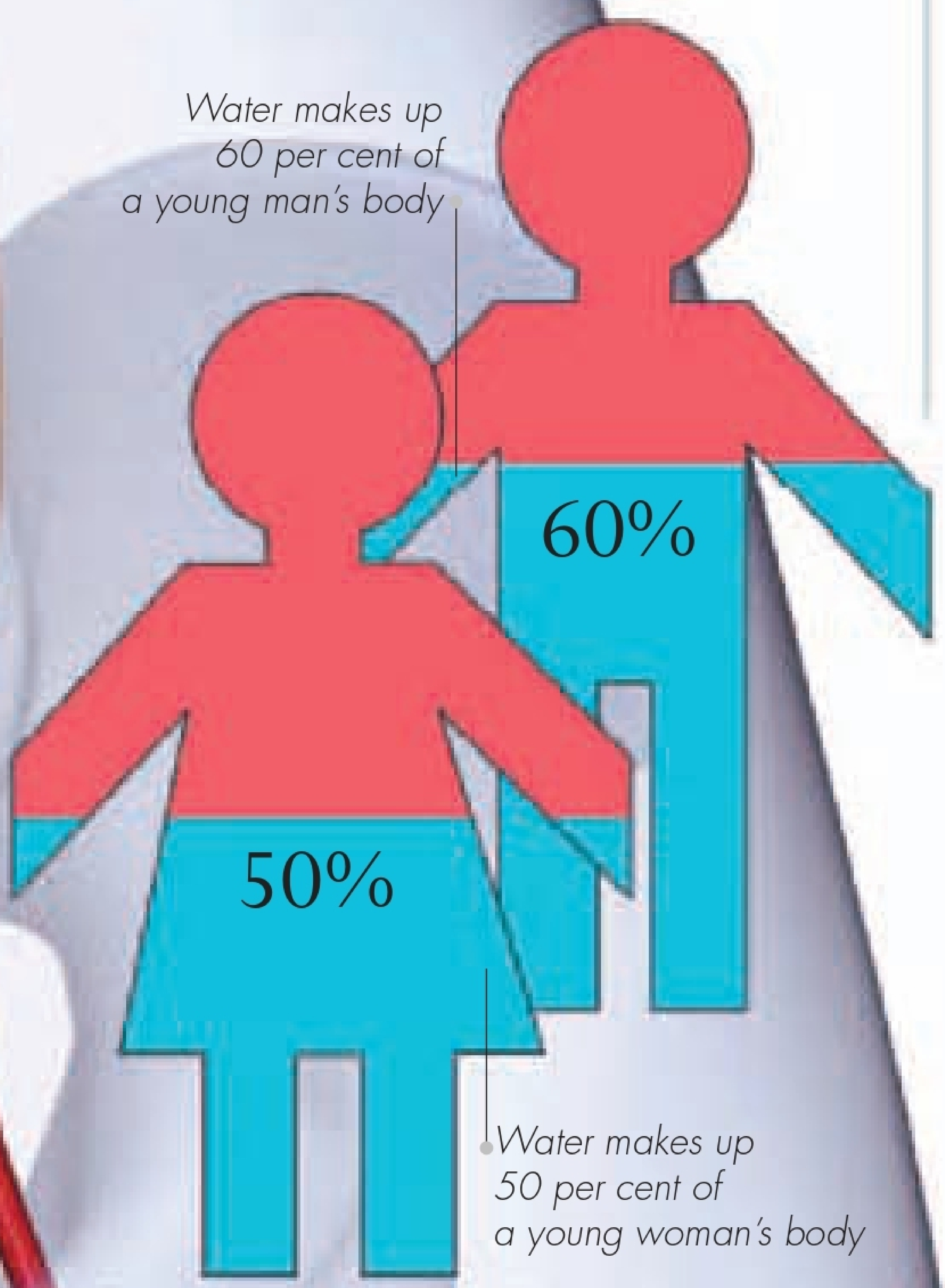
Q/A Your bladder has an elastic wall that stretches as it fills with urine. You can see how much the bladder (green) expands in these X-rays (below). As the bladder fills up, stretch sensors in its wall send messages to your brain telling you that it's time to go to the loo.

Full bladder



Empty bladder





A urine sample, ready for testing

Why is urine yellow?

Urine contains various dissolved substances, one of which gives urine its yellow colour. To help them discover why patients are ill, doctors check the levels of certain substances in urine to see if they are abnormal. A test stick is dipped into a patient's urine sample. Its coloured bands detect specific substances and change colour to show how much of each is present.

How much water is in my body?

Water is really important. It is a major part of blood, and without water your cells would not work. A child's body is around 65 per cent water. After puberty, water content depends on a person's sex. Women contain less water than men because they have more body fat – a tissue that contains little water.

A sweating rock climber

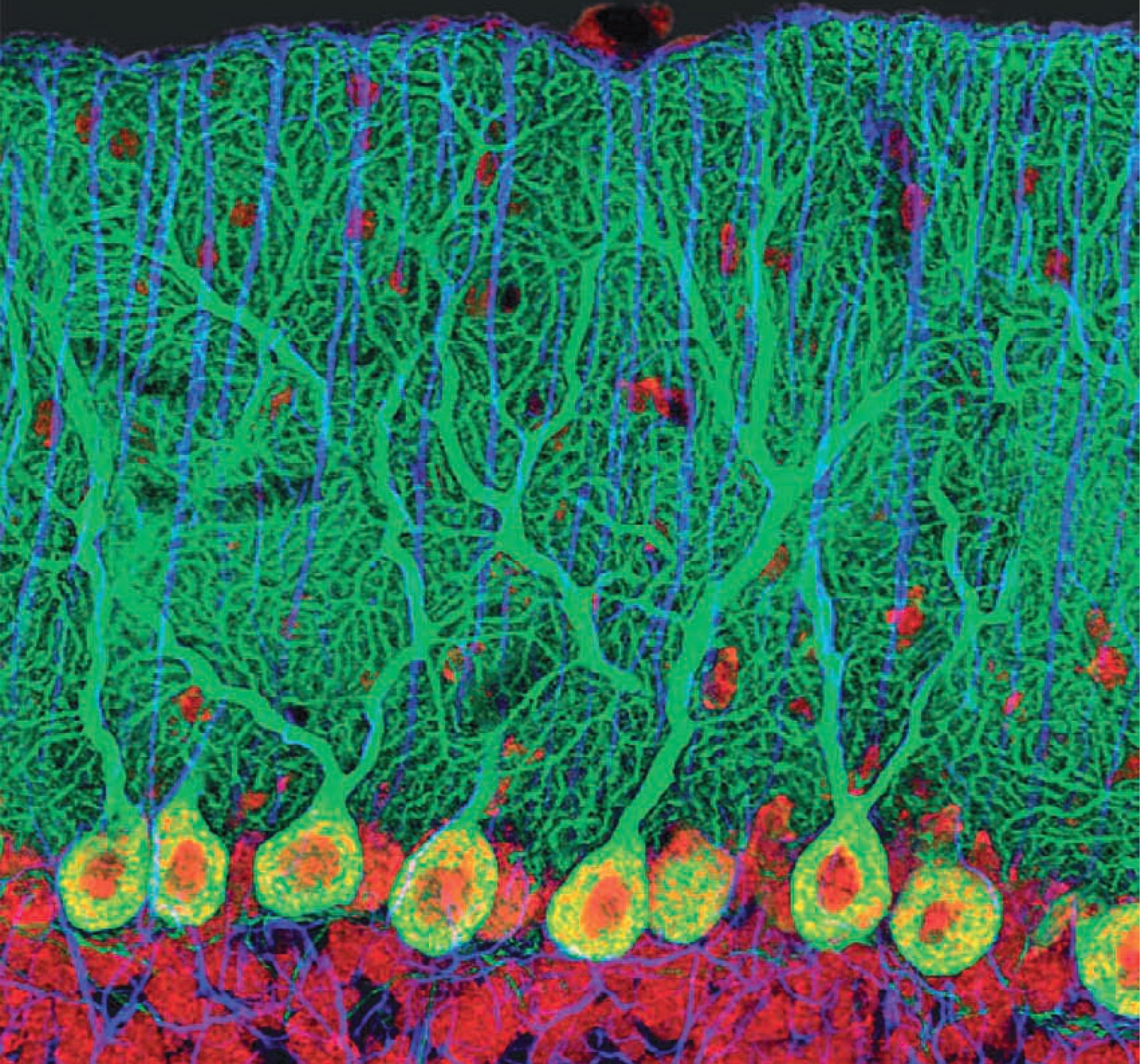
What makes me feel thirsty?

Whenever you sweat, wee, or breathe out, your body loses some of its water. This makes your mouth feel dry and your blood more concentrated, which is detected by the "thirst centre" in your brain. The thirst centre makes you feel thirsty so that you feel the need to drink. The drink wets your mouth, quenches your thirst, and replaces the lost water.

More Facts

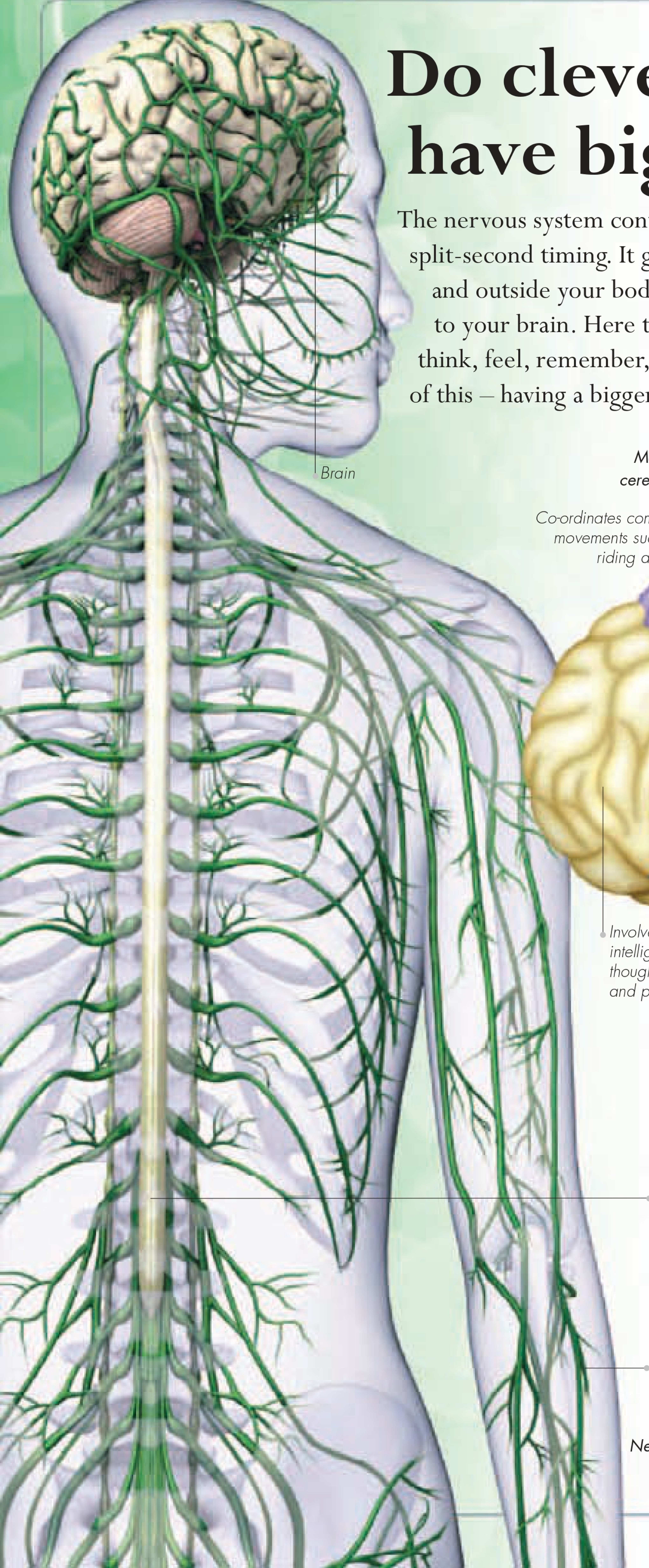
- Babies can't control when they wee. Once a baby's bladder is full, it empties automatically.
- Your kidneys process 1,750 litres (3,080 pints) of blood and filter about 180 litres (317 pints) of fluid into the nephrons, but release just 1.5 litres (2.6 pints) of urine per day.
- Water makes up about 95 per cent of urine. The major waste dissolved in urine is urea – a substance produced by liver cells.
- To keep your water content the same, the kidneys release more, dilute urine if you have drunk lots of fluid, and less urine that is more concentrated if you are dehydrated and sweating.

Brainpower

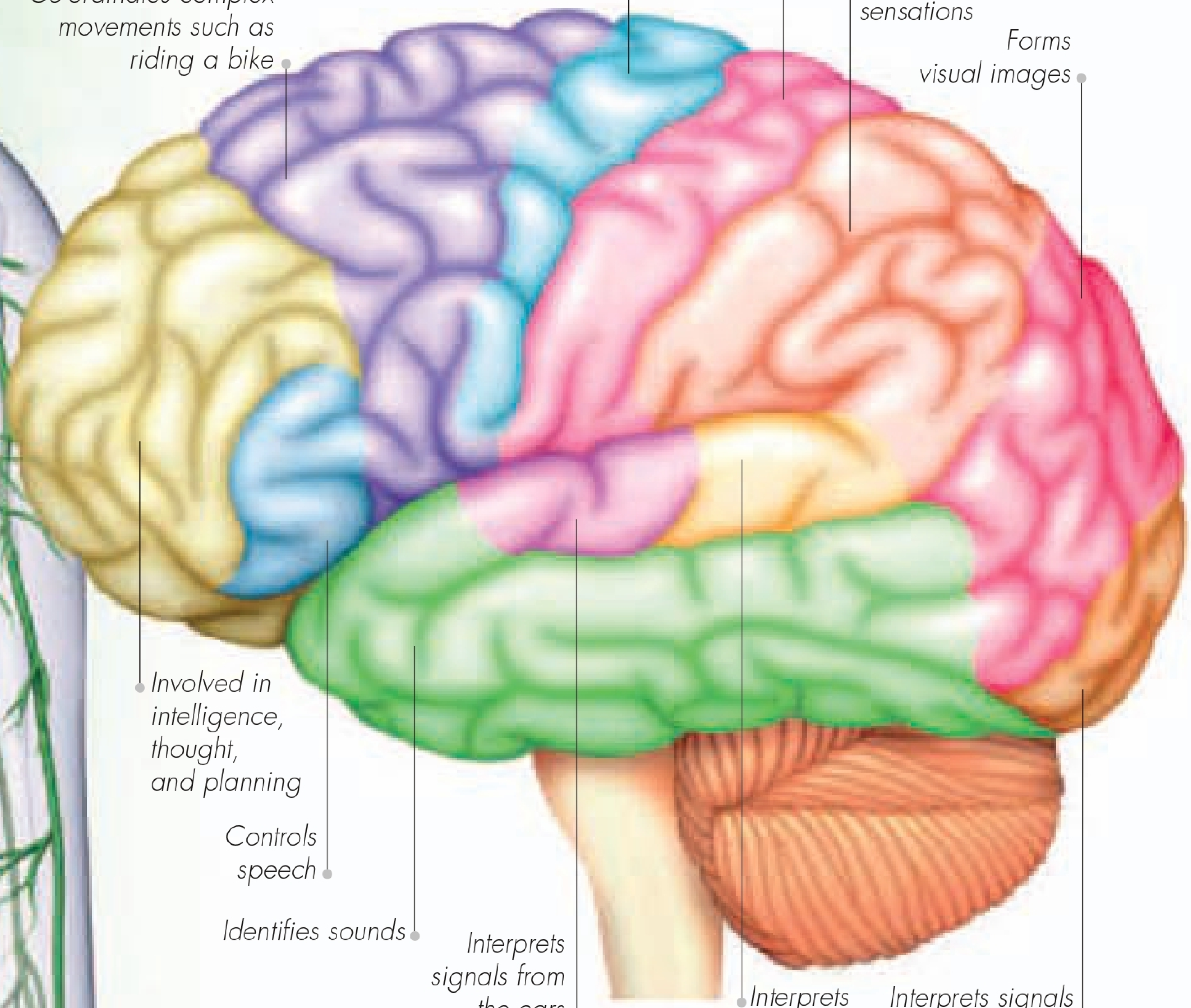


Do clever people have bigger brains?

The nervous system controls and co-ordinates your body's activities with split-second timing. It gathers information about what is happening inside and outside your body and sends it along nerves and the spinal cord to your brain. Here the information is processed, enabling you to think, feel, remember, and move. Your brain's size doesn't affect any of this – having a bigger brain does not make you any more clever.



Nervous system



Map of the cerebral cortex

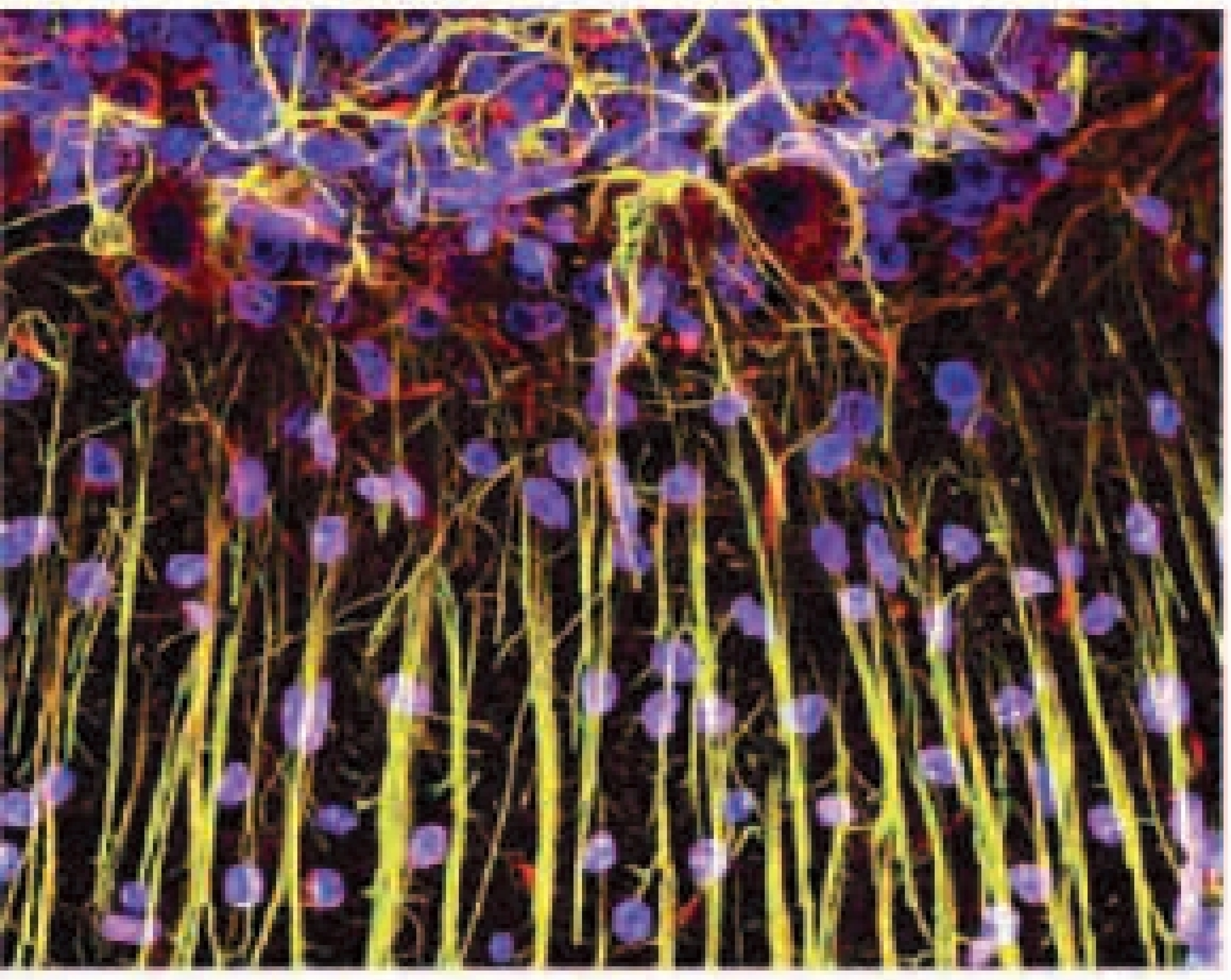
Q Which part of my brain does what?

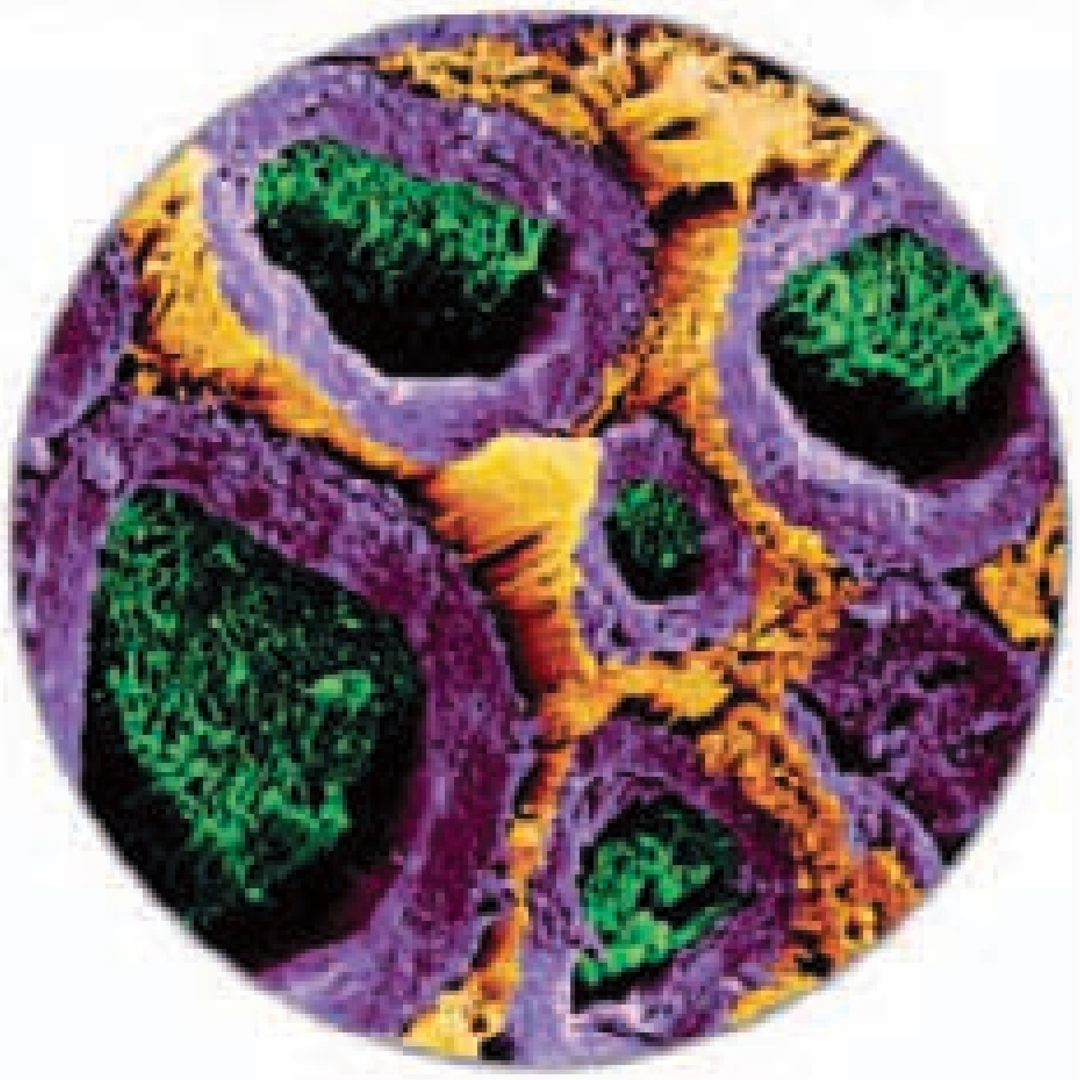
A The largest part of your brain is the wrinkled cerebrum. Its thin outer layer, the cerebral cortex, receives and processes information and sends out instructions, and also stores memories. Different areas of your cerebral cortex – such as the "thinking" region at the front of your brain – have distinct jobs to do, as you can see from this "map".

How do I react so quickly?

Your nervous system is constructed from a massive network of interconnected cells called neurons. The brain alone contains 100 billion neurons. Each neuron has a long, narrow extension called a nerve fibre that generates and transmits electrical signals called impulses at very high speed. This allows you to instantly react to events even if the signal has to travel all the way from your big toe to your brain.

Neurons in the brain





Section through nerve

What is a nerve?

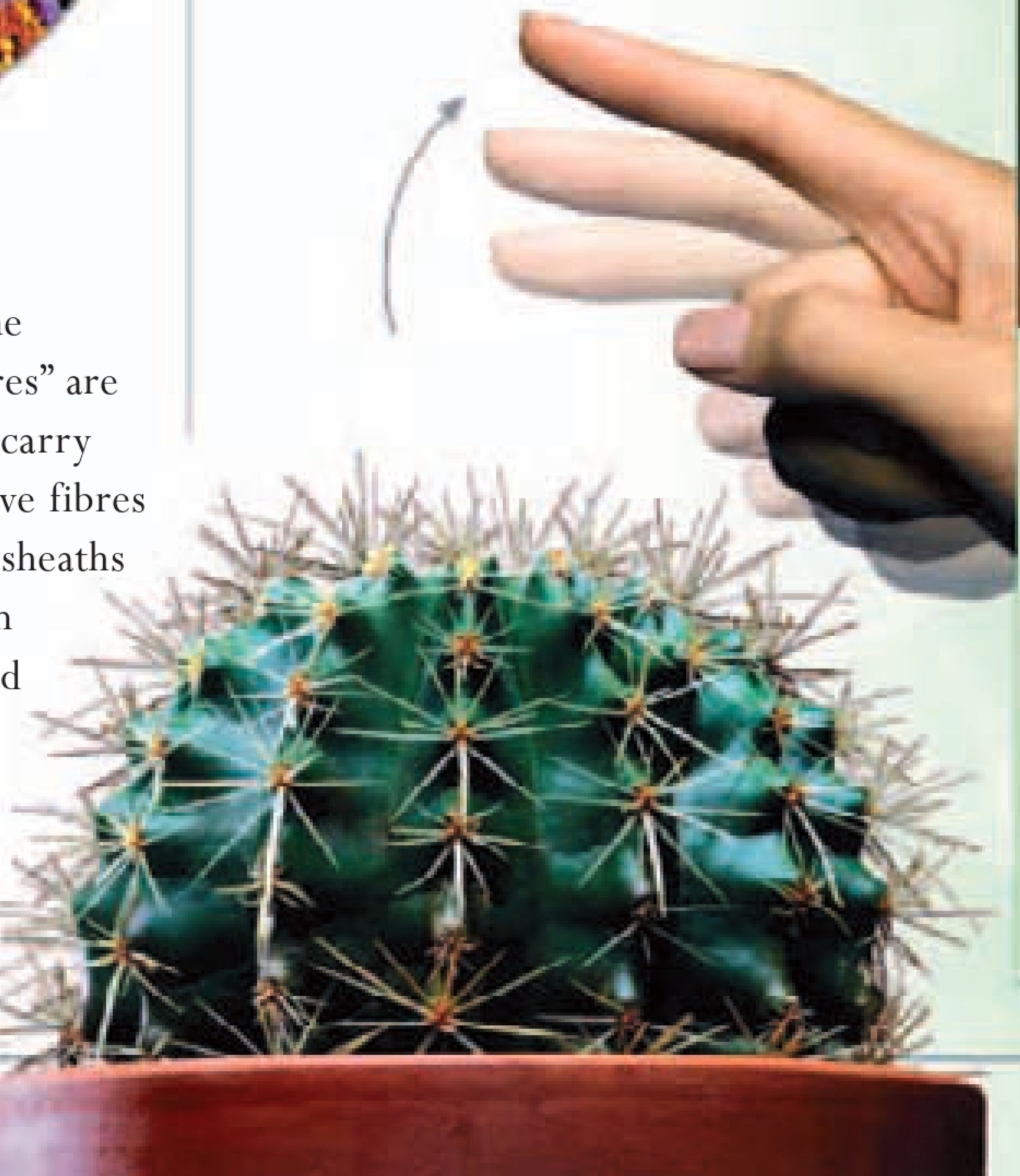
Nerves are the cables of the nervous system. Their "wires" are the long nerve fibres (green) that carry high-speed signals. Bundles of nerve fibres are protected by tough but bendy sheaths (purple). Nerves relay information from sensors to the spinal cord and brain about what is happening to the body. They also carry instructions the opposite way to muscles and other organs.

Painting with the left hand

How can reflexes protect me from danger?

If you touch something sharp or very hot, you automatically pull your hand away without thinking about it. This is an example of a reflex – an action that is rapid, unchanging, and protects us from harm. Pain signals from your fingers travel to your spinal cord. This sends instructions to your arm muscles to move your hand at the same time as signals reach your brain so that you feel pain.

Withdrawal reflex

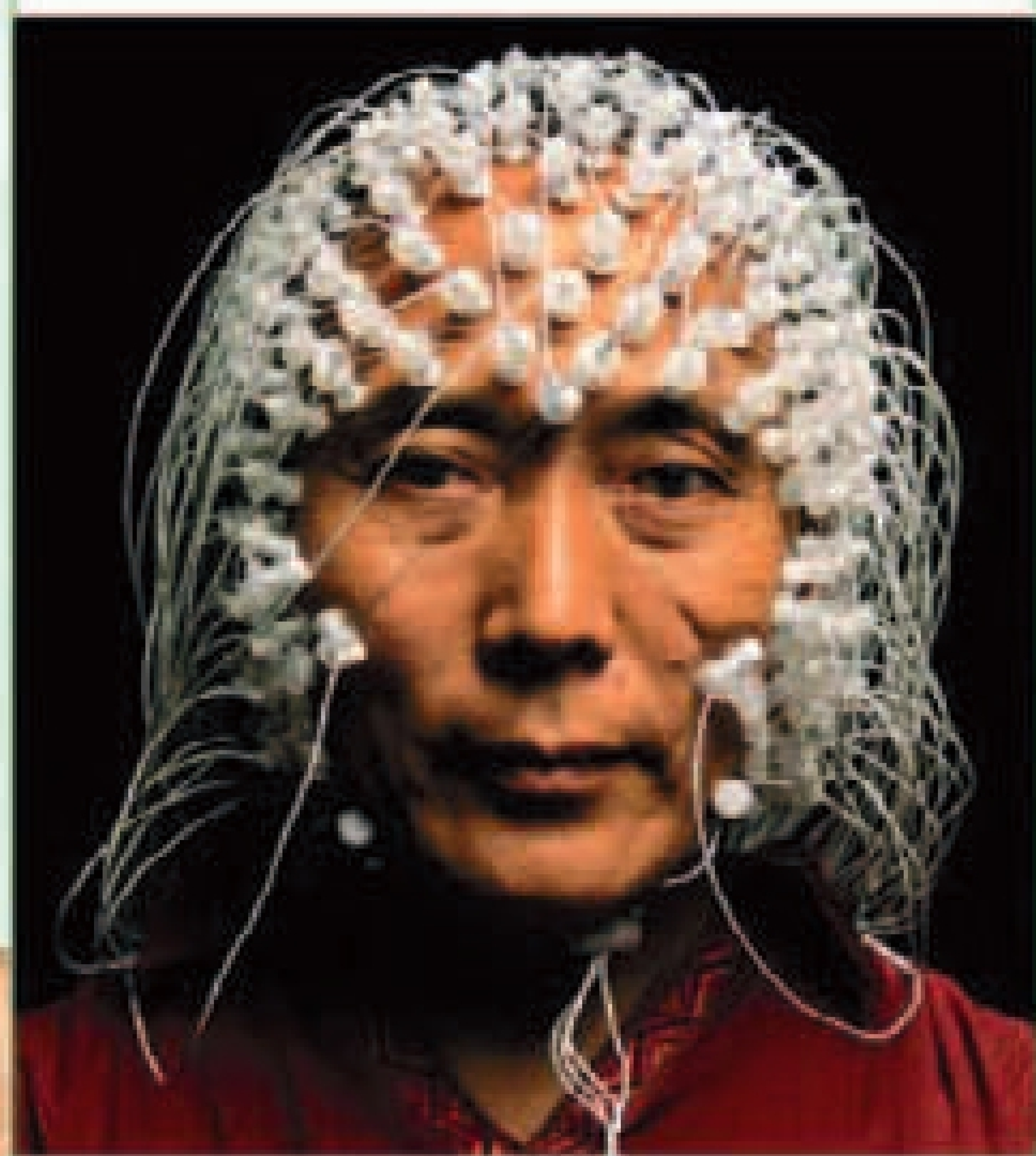


Why are some people left handed?

The main part of your brain, the cerebrum, has left and right sides. The left side controls the right side of your body and vice versa. Normally the left side dominates, which explains why most people are right handed. But in about 10 per cent of people the right side is dominant so they are left handed.

More Facts

- Your brain makes up just 2 per cent of your body weight but uses 20 per cent of your oxygen intake to release energy to keep it working.
- Busy brain neurons create patterns of electrical activity called brain waves, which can be detected by attaching electrodes to the scalp.

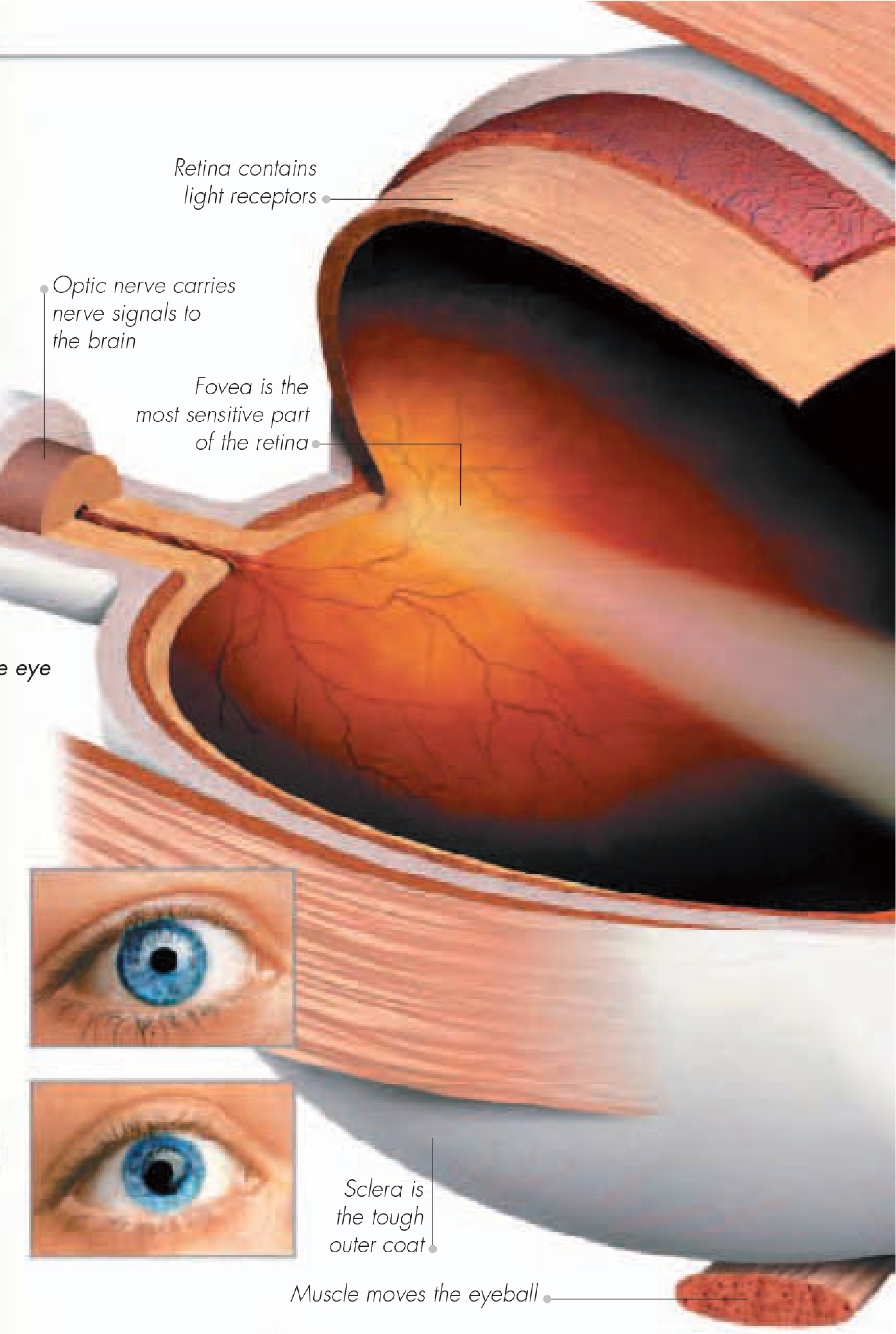


Detecting brain waves

- Your brain doesn't switch off when you sleep, although its brain waves change. At night your brain sorts and stores information, making you dream.
- The left side of your cerebrum deals with maths, language, and problem solving. The right side focuses on art, music, and creativity.

Why can't I see in the dark?

Vision is our most important sense. It allows us to see our surroundings. The sense organs responsible for vision are the eyes. Moving constantly, the eyes collect light and focus it onto receptor cells. These send signals to the brain, which creates images that we can see. In the dark there is little or no light so we are unable to see.

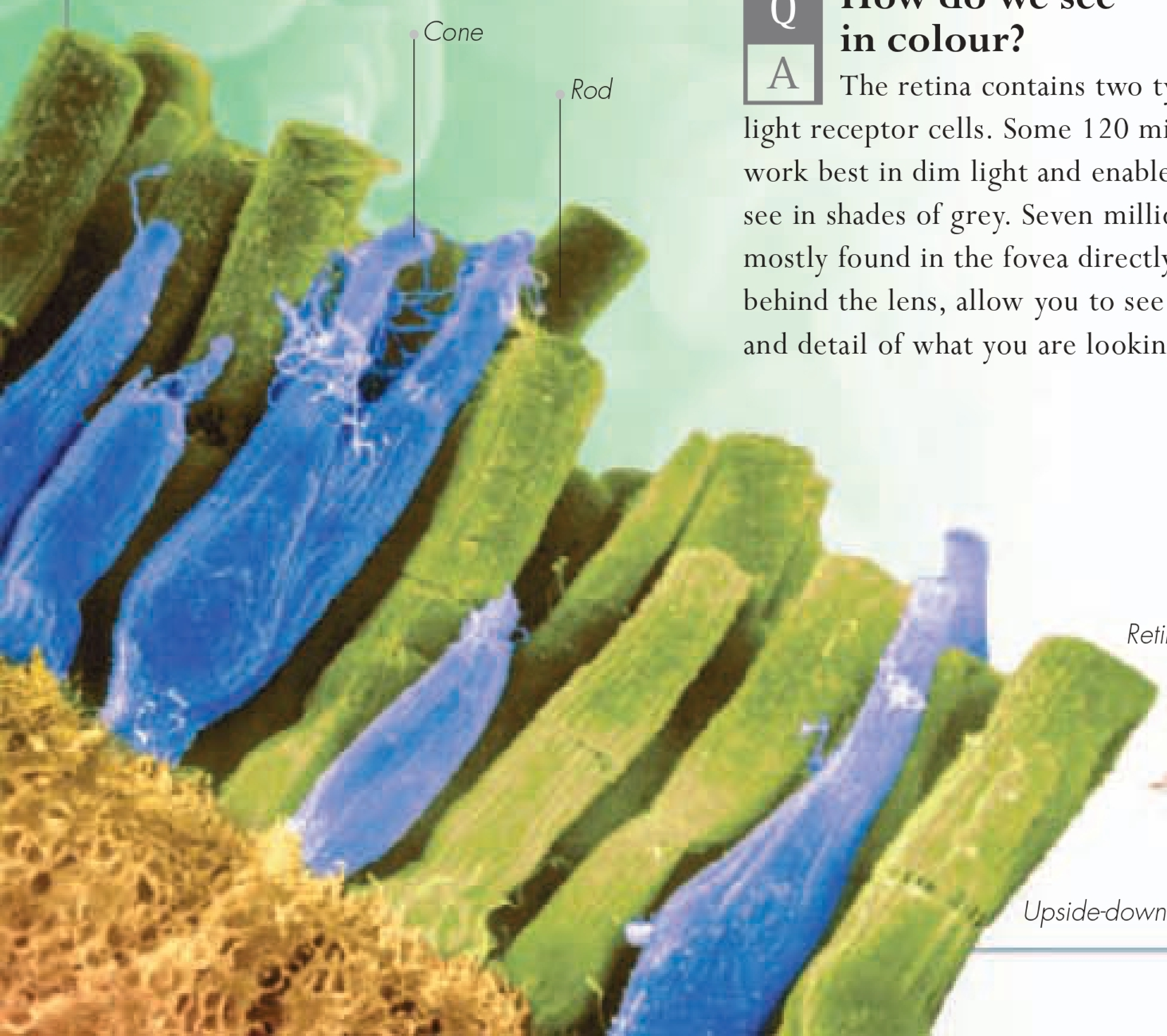


Structure of the eye

Q Why do my pupils change size?

A Your coloured irises automatically control the size of your pupils and, therefore, the amount of light that enters your eyes. Without this control you would be dazzled in bright light and unable to see in dim light. Circular muscle fibres in your irises close your pupils in bright light, and spoke-like radial muscle fibres contract to open your pupils in dim light.

Light receptor cells

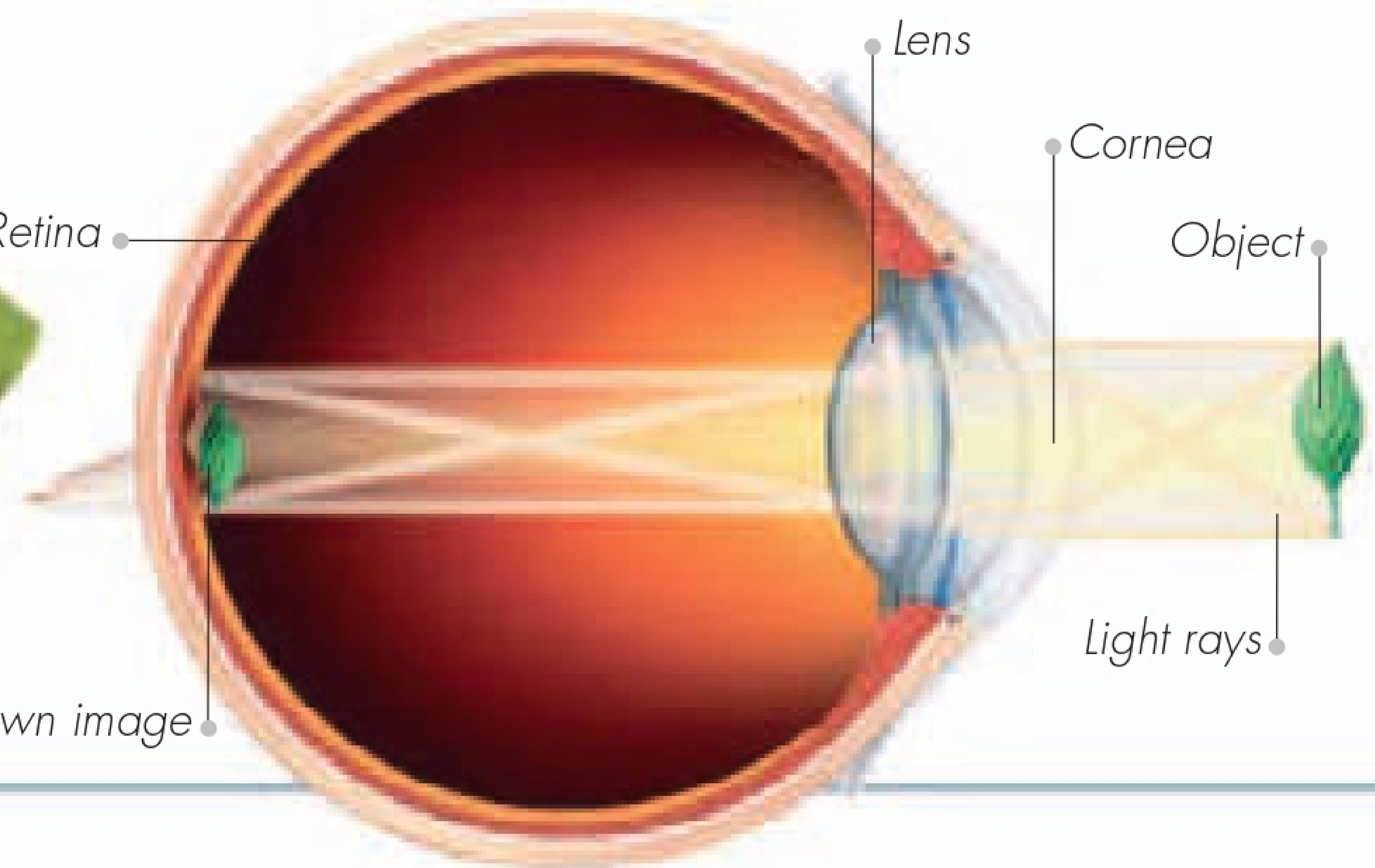


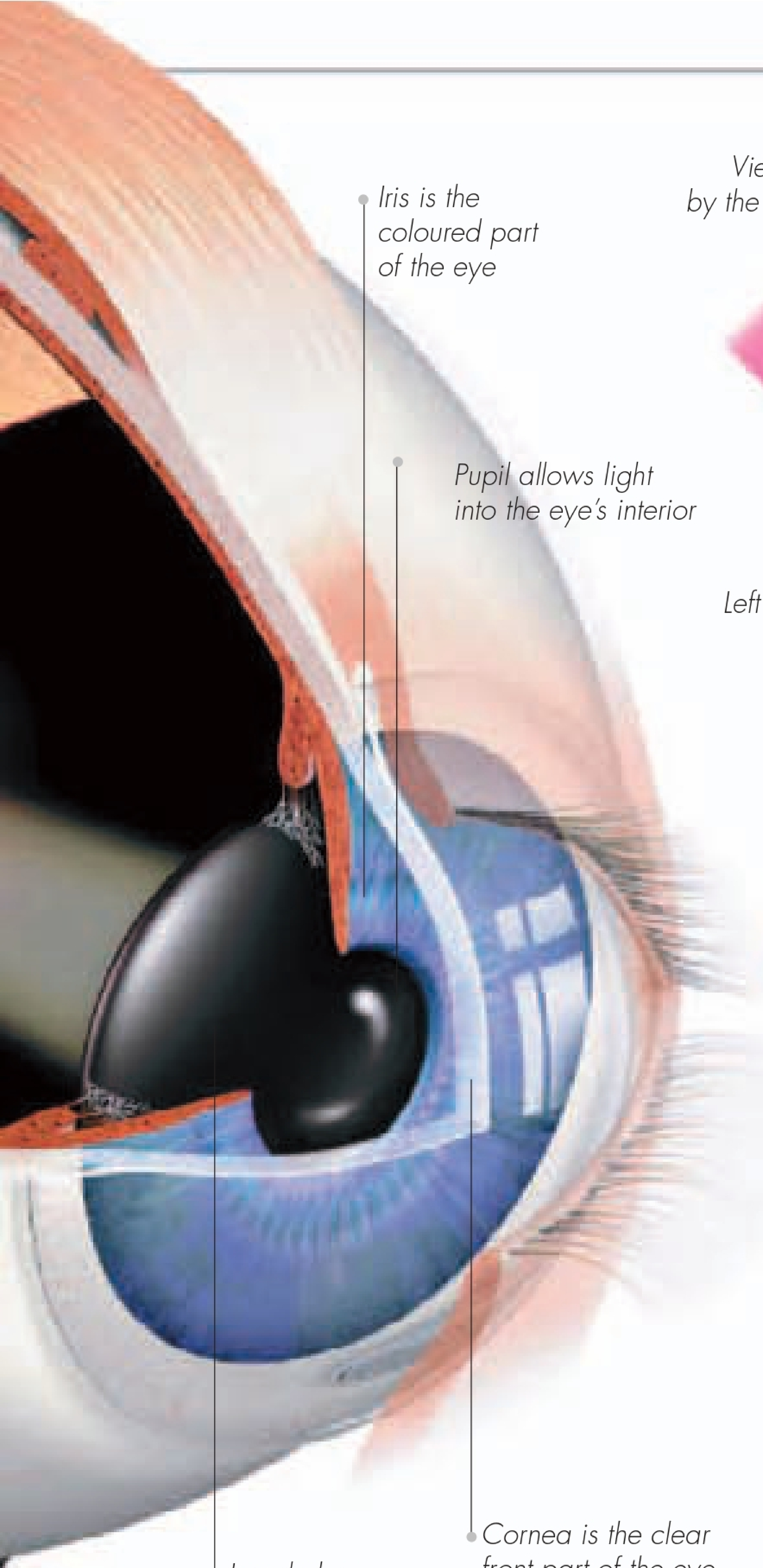
Q How do we see in colour?

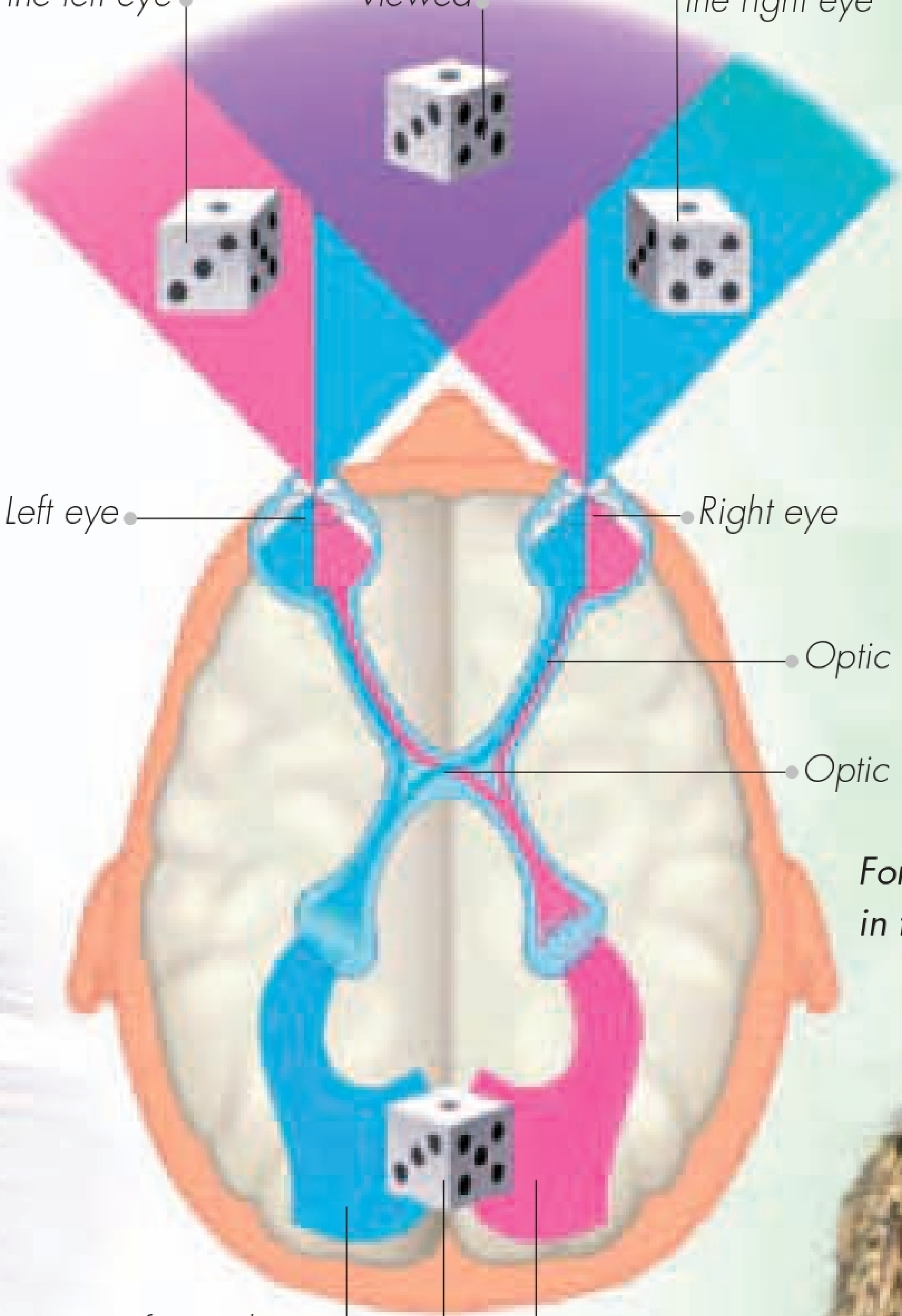
A The retina contains two types of light receptor cells. Some 120 million rods work best in dim light and enable you to see in shades of grey. Seven million cones, mostly found in the fovea directly in line behind the lens, allow you to see the colour and detail of what you are looking at.

Q Is an eye similar to a camera?

A Cameras use lenses to focus light rays from an object to form an image on a light-sensitive surface. The eyes are no different. Light rays from an object are focused automatically, whatever its distance from the eyes, by the cornea and lens to form an upside-down image on the retina. This sends signals to the brain which enables you to "see" the object the right way up.







Forming images in the brain

How can I see in 3-D?

Looking at this dice, your left eye has a different view to your right. Information about each view passes along the optic nerves. At the optic chiasma signals from the left side of each eye go to the left visual area of your brain, while those from the right side of each eye go to the right visual area. Your brain compares these signals to recreate the original object in 3-D and to work out how far away it is.

Jumping spider

More Facts

- Jumping spiders have eight eyes, including two large, forward-facing eyes that enable it to judge distances very accurately and pounce on unwary prey.
- Your eyes contain more than 70 per cent of your body's sensory receptors. They can detect and distinguish between some 10,000 different colours.
- Just one sixth of the eyeball is visible from the outside. The rest is protected inside the bony eye socket, with extra protection from the eyelids, eyelashes, and eyebrows.
- Your eyes are never still. As well as following moving objects, they also make tiny jumping movements called saccades that scan objects in view.

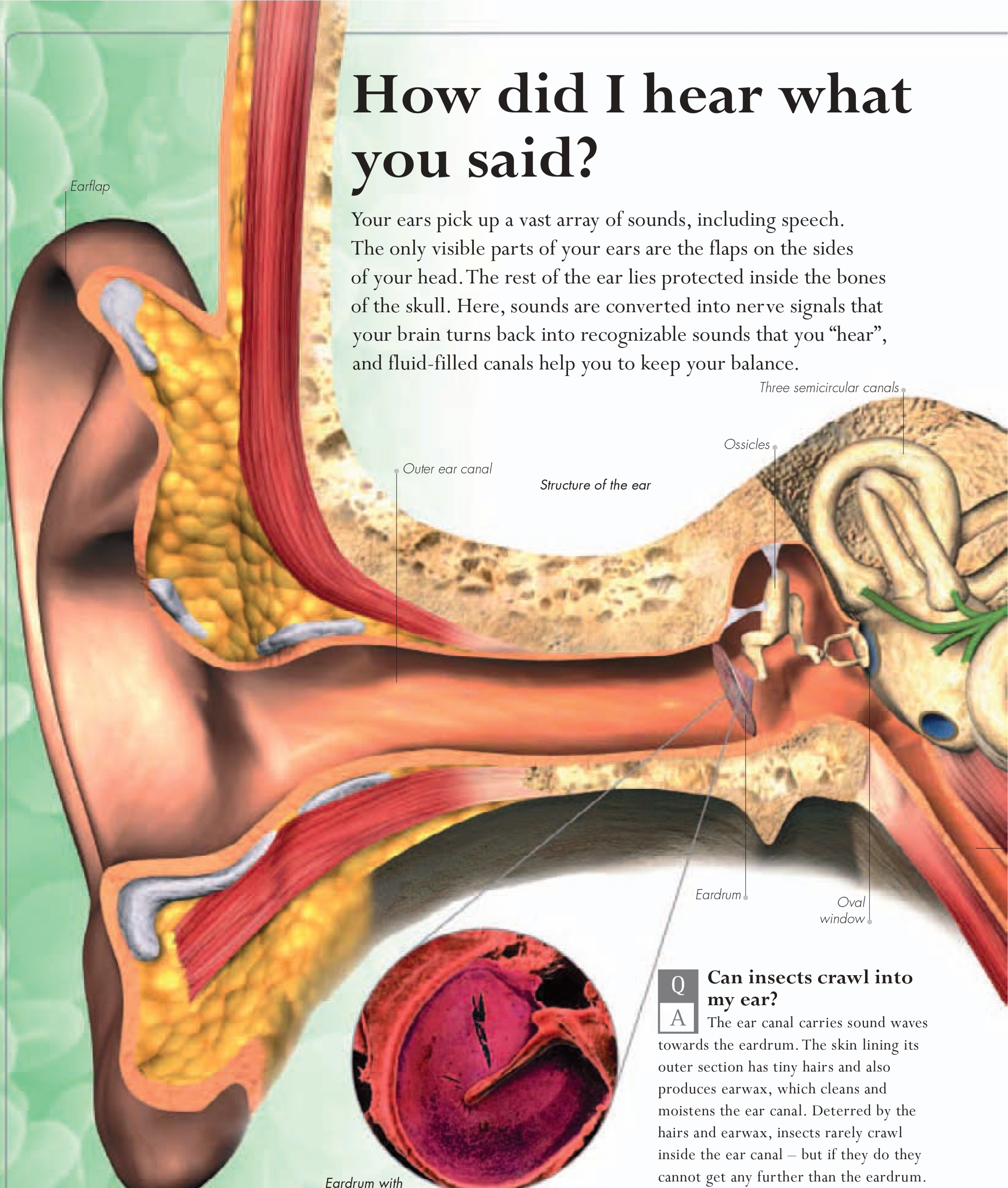
What makes us cry?

Tear glands below your eyebrows produce watery tears that wash over your eyeballs. There are three types of tears. Basal tears are released constantly to wash away dust, moisten your eyes, and kill bacteria. Reflex tears are a response to irritants such as onion odours or bright light. Emotional tears, unique to humans, flow when you are very sad, happy, or in pain, and contain natural painkillers.

Emotional crying

How did I hear what you said?

Your ears pick up a vast array of sounds, including speech. The only visible parts of your ears are the flaps on the sides of your head. The rest of the ear lies protected inside the bones of the skull. Here, sounds are converted into nerve signals that your brain turns back into recognizable sounds that you "hear", and fluid-filled canals help you to keep your balance.



Structure of the ear

Eardrum with hammer(ossicle)

Q Can insects crawl into my ear?

A The ear canal carries sound waves towards the eardrum. The skin lining its outer section has tiny hairs and also produces earwax, which cleans and moistens the ear canal. Deterred by the hairs and earwax, insects rarely crawl inside the ear canal – but if they do they cannot get any further than the eardrum.

What are sound waves?

Q

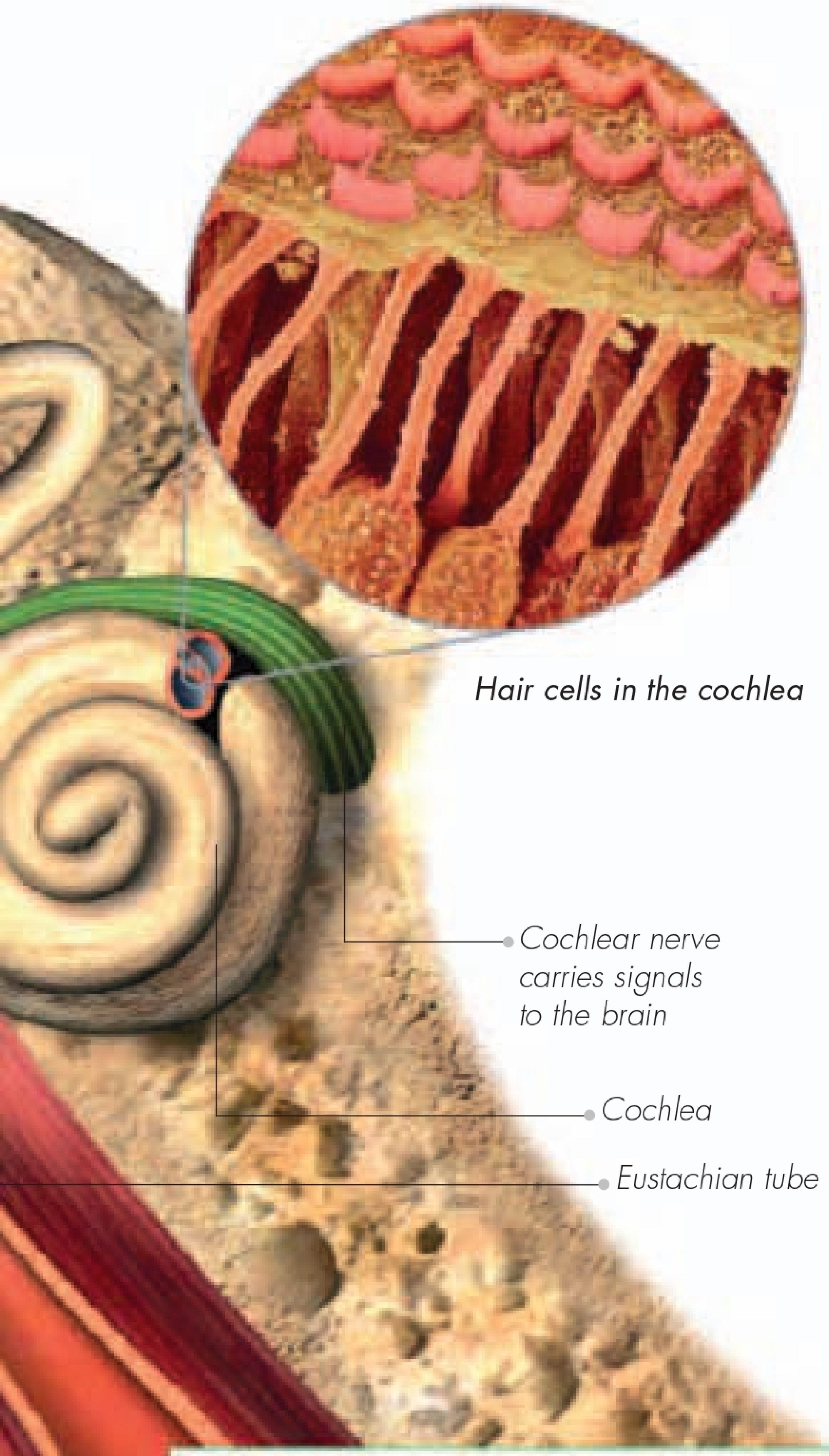
A Anything that moves or vibrates creates waves of pressure, called sound waves, that travel through the air. On entering your ear they make the eardrum vibrate. This, in turn, sets up pressure waves in the fluid-filled cochlea of the inner ear. These bend tiny "hairs" on the cochlea's hair cells causing them to send signals to the hearing part of your brain.

Are there any bones in my ear?

Q

A Linking the eardrum to the inner ear are three small bones, or ossicles, individually named the hammer, anvil, and stirrup after their shapes. The smallest, the stirrup is even tinier than the anvil shown here. The ossicles form a bony chain that transmits sound vibrations from the eardrum to the oval window – the entrance to the inner ear.

Anvil bone on a fingertip



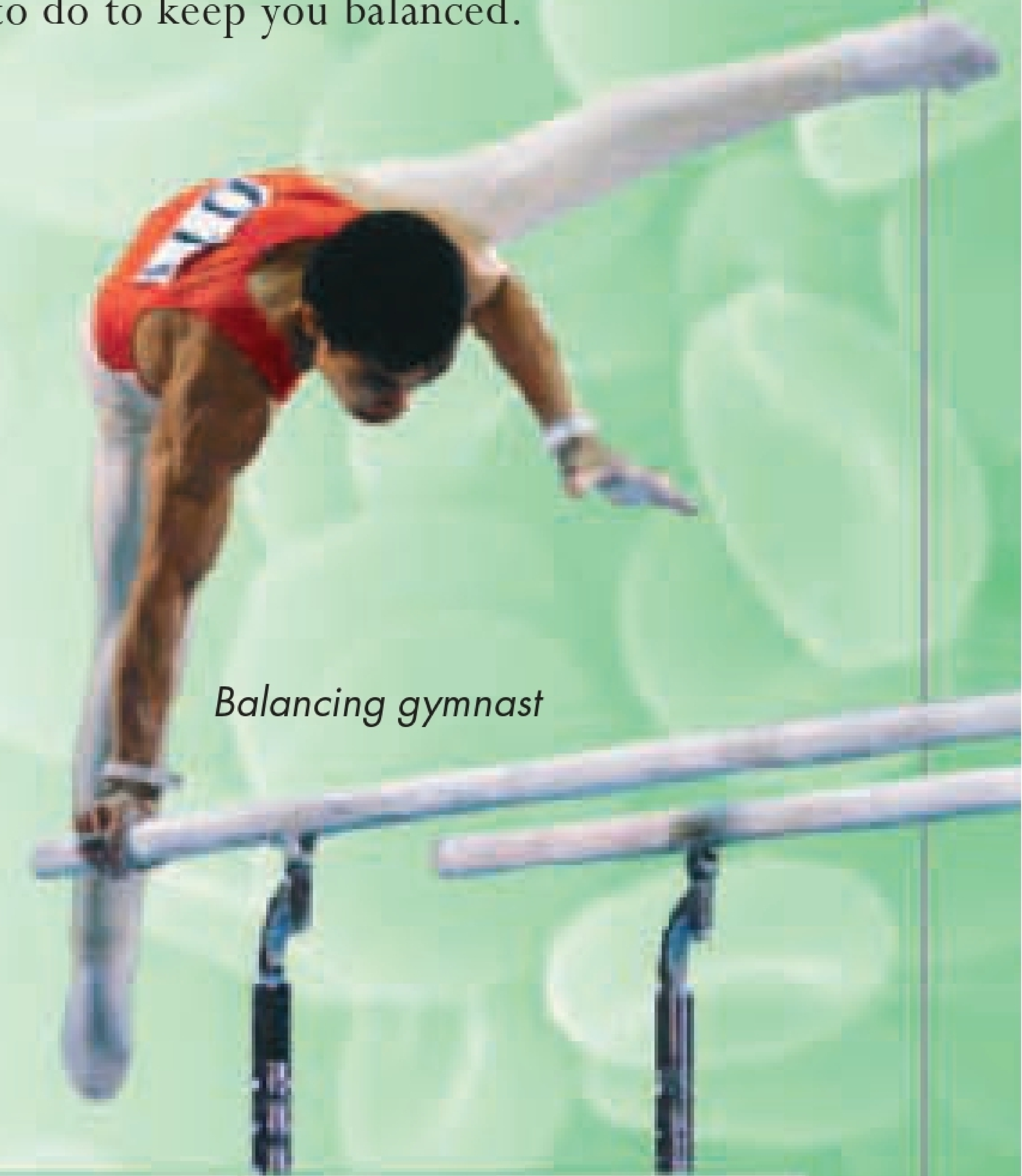
Hair cells in the cochlea

Listening to an mp3 player

How do ears help us to balance?

Q

A The inner ear contains three semicircular canals, arranged at right angles to each other. These, and other inner ear sensors, keep your brain updated about the movement and position of your head. Your brain uses this information, together with input from your eyes, to tell your muscles what to do to keep you balanced.



Balancing gymnast

Can loud noise damage my ears?

Q

A Your ears can distinguish between a massive range of sound volumes, and have a built-in mechanism to protect the inner ear from sudden loud noises. But long-term exposure to loud sounds, such as constantly listening to loud music through earphones, can damage the cochlea's delicate hair cells and lead to deafness.

More Facts

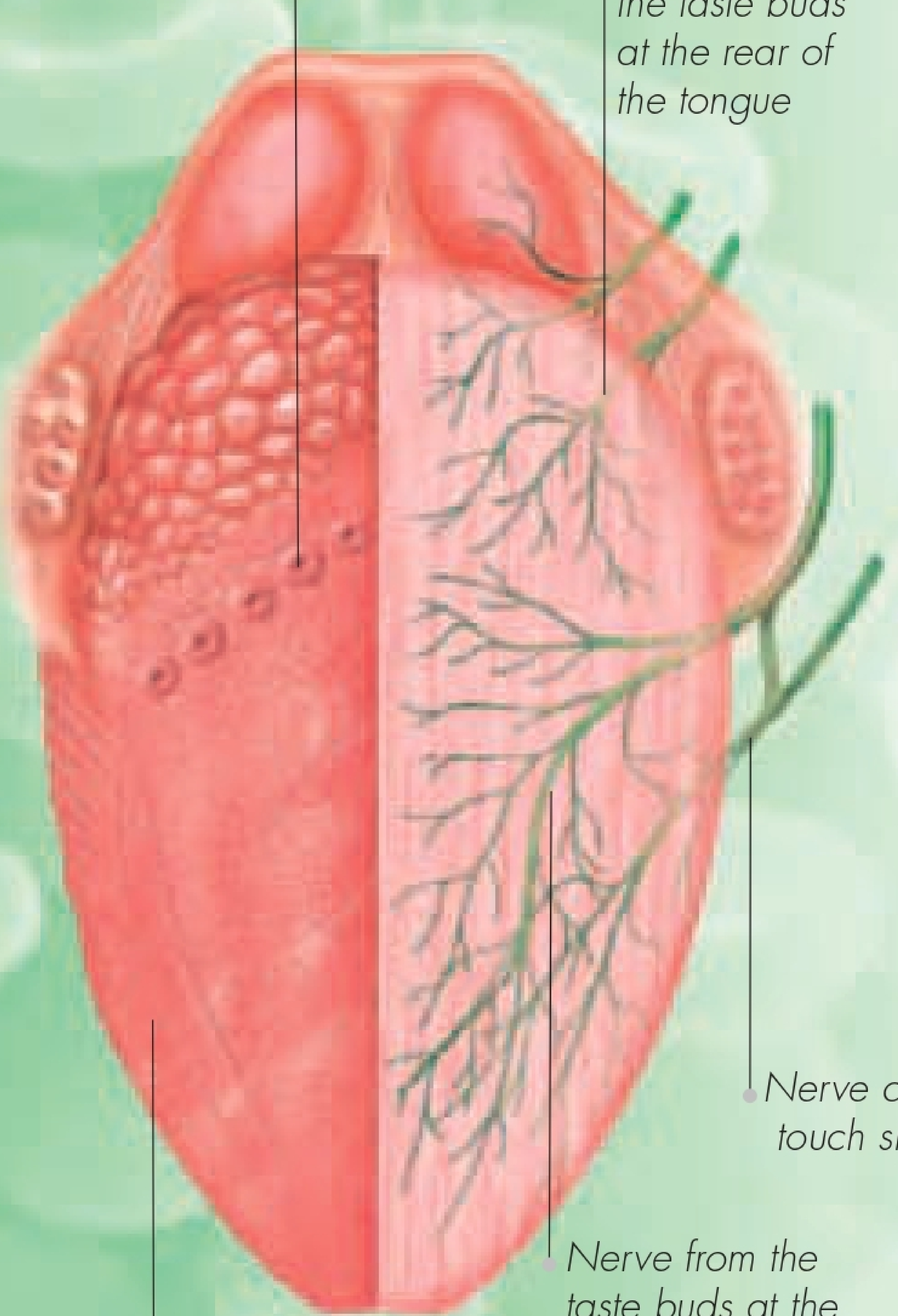
- The Eustachian tube links your ear to your throat and keeps air pressure inside and outside the ear equal. A sudden pressure change, such as when a plane takes off, makes hearing difficult. But if you yawn or swallow, the tube widens to equalize pressure, making your ears pop.

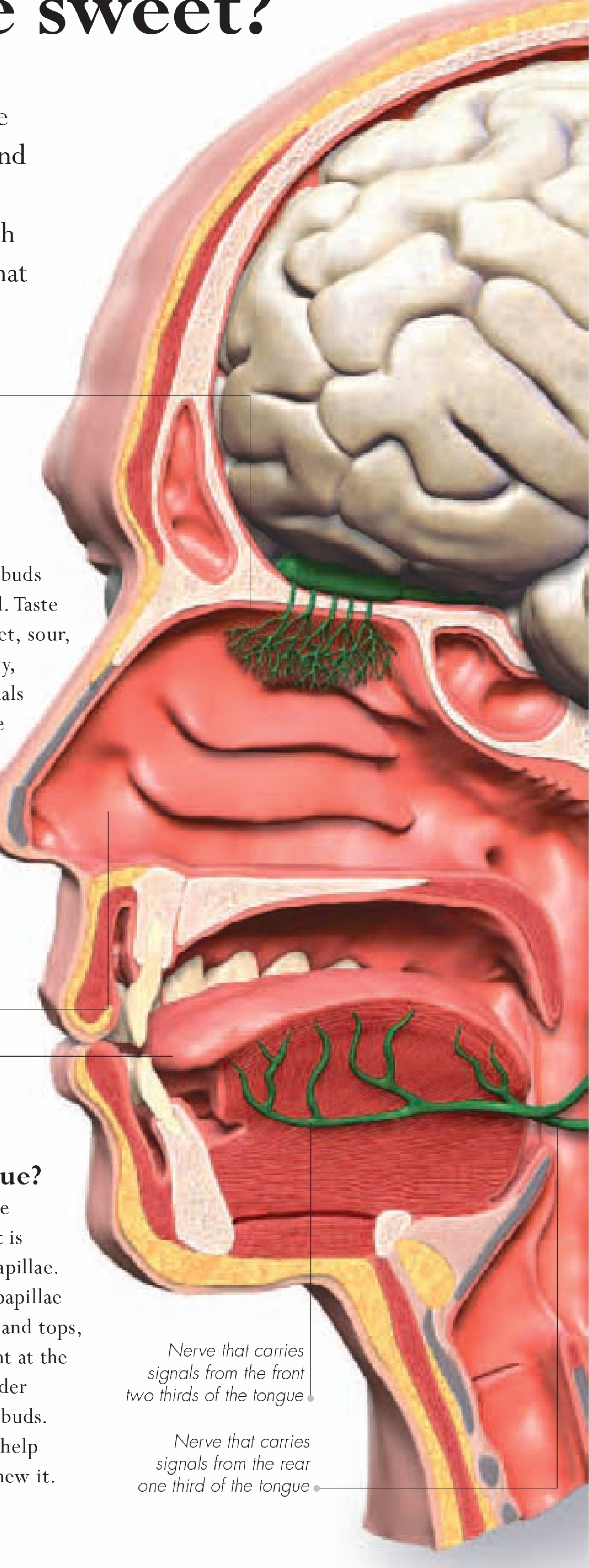
Planes taking off

- Sounds reach one ear a split second before the other. This allows your brain to work out which direction the sounds came from.
- Younger people can hear a much wider range of sounds than older people.
- Animals such as cats and bats can hear very high-pitched sounds that we cannot.

Why do sweets taste sweet?

Being able to smell and taste allows us to enjoy food and drink and many other aspects of life. The senses of smell and taste are closely linked; both are located in the head – one in the nose and the other in the mouth. Both detect chemicals that are carried in the air (smell) or food (taste). And they help us to distinguish between the sweetness of sweets, and the bitterness of foods that might be poisonous.



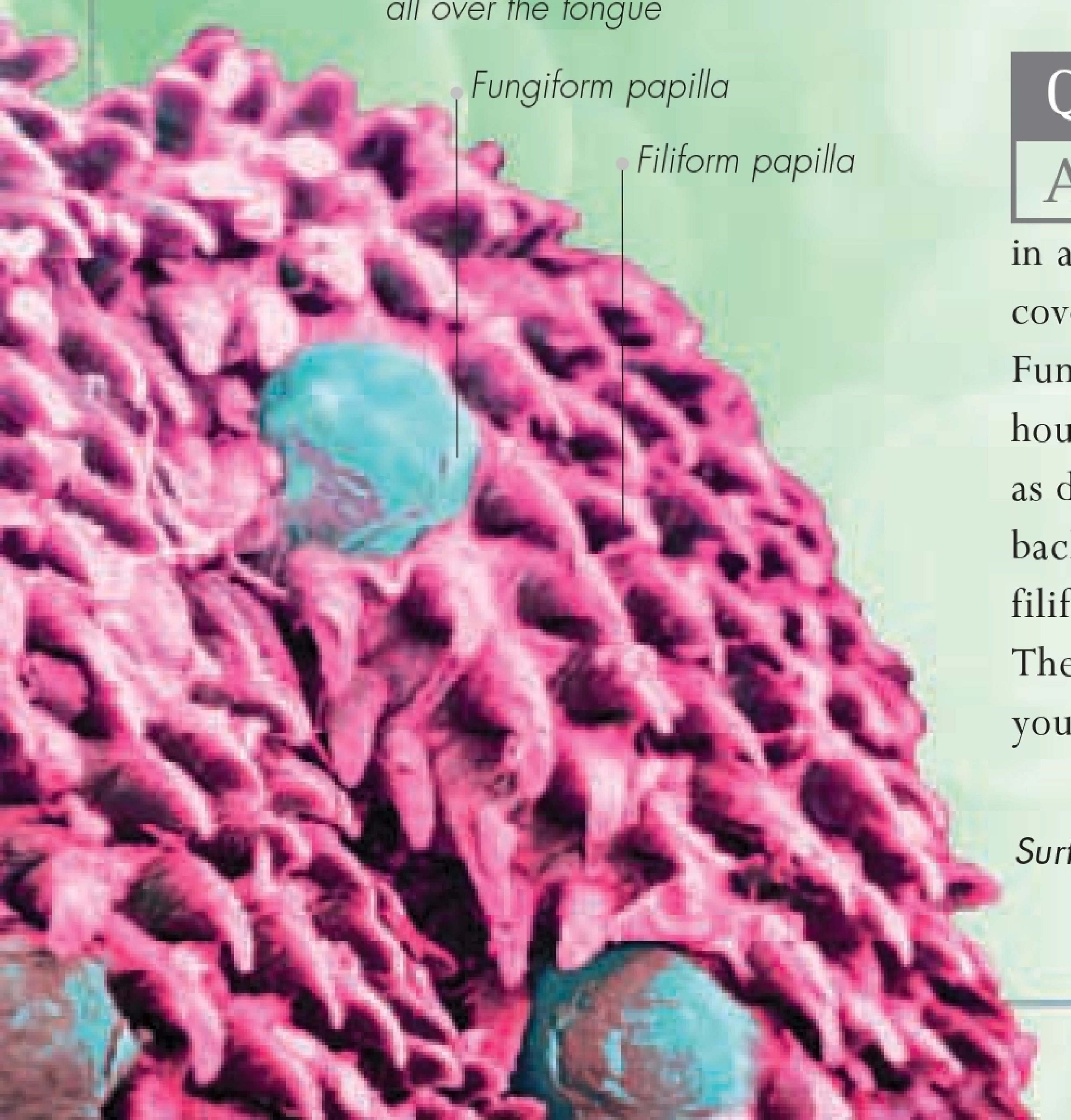


Q How do taste buds work?

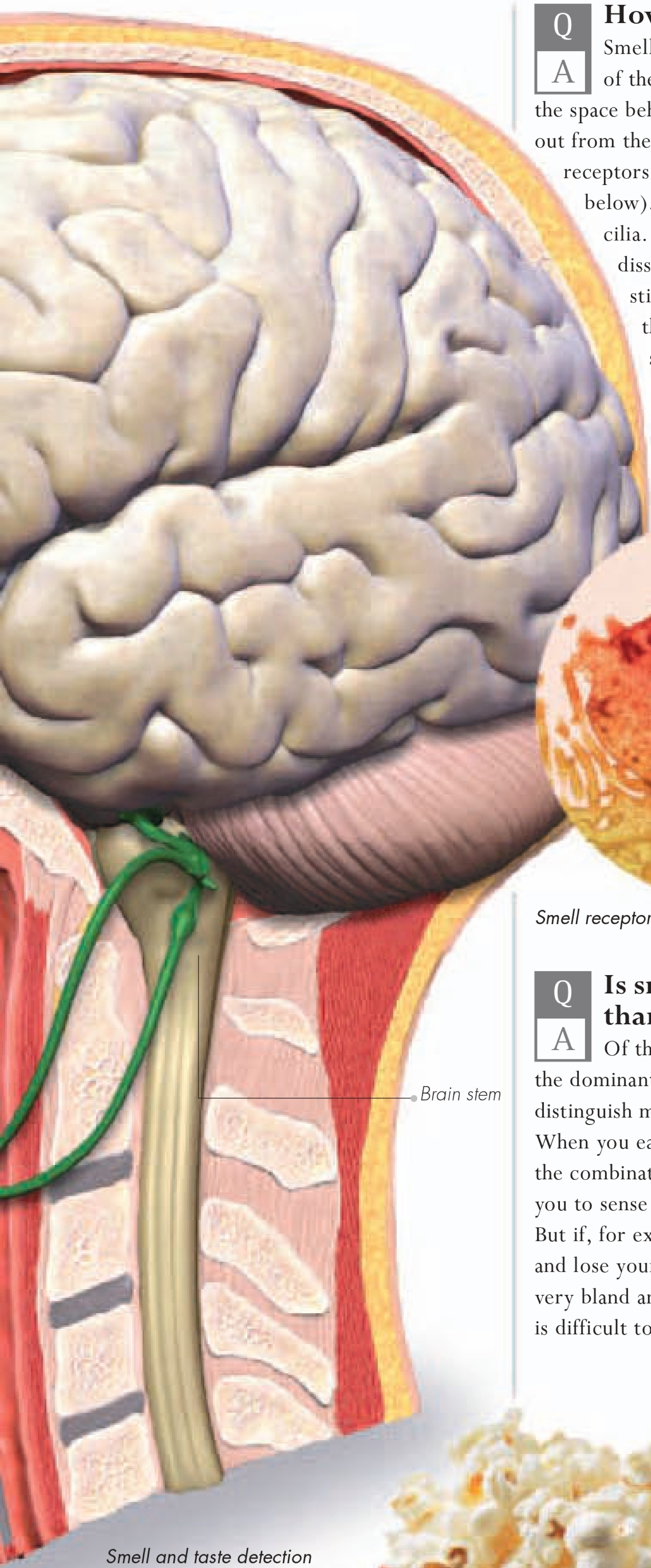
A Your tongue has about 10,000 tiny receptors called taste buds that detect taste molecules in food. Taste buds detect five basic tastes – sweet, sour, salty, bitter, and umami – a savoury, meaty taste. Two nerves carry signals from taste buds to the brain. Some parts of the tongue may be more sensitive to certain tastes. Other receptors in the tongue detect the texture and temperature of food.

Q What are the tiny bumps on my tongue?

A Look closely at your tongue in a mirror and you will see that it is covered with tiny bumps, called papillae. Fungiform ("mushroom-shaped") papillae house the taste buds in their sides and tops, as do the large vallate papillae right at the back of the tongue. The more slender filiform papillae do not have taste buds. They contain touch receptors and help your tongue to grip food as you chew it.



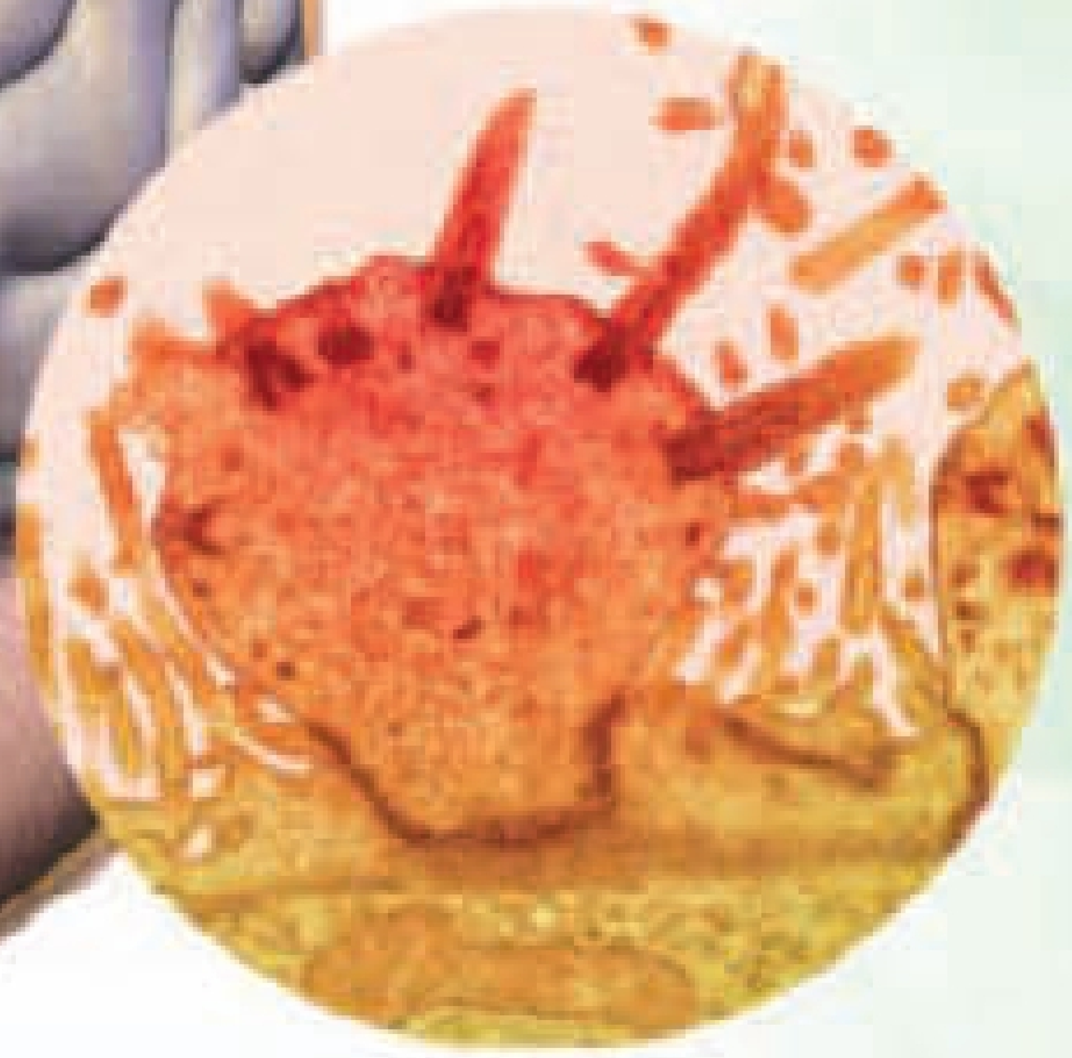
Surface of the tongue



Smell and taste detection

How do I smell things?

Smelling happens in the lining of the roof of your nasal cavity – the space behind your nose. Sticking out from the lining are the tips of smell receptors, which look like this (see below). Each tip has several hair-like cilia. Breathed-in molecules dissolve in watery mucus and stick to these cilia. This causes the smell receptors to send signals to the brain, which identifies what you are smelling.



Smell receptor

Is smell more important than taste?

Of the two senses, smell is the dominant partner because you can distinguish many more odours than tastes. When you eat food, such as popcorn, the combination of smell and taste allows you to sense and appreciate its flavours. But if, for example, you have a bad cold and lose your sense of smell, food tastes very bland and, if you close your eyes, is difficult to identify.

Fresh popcorn

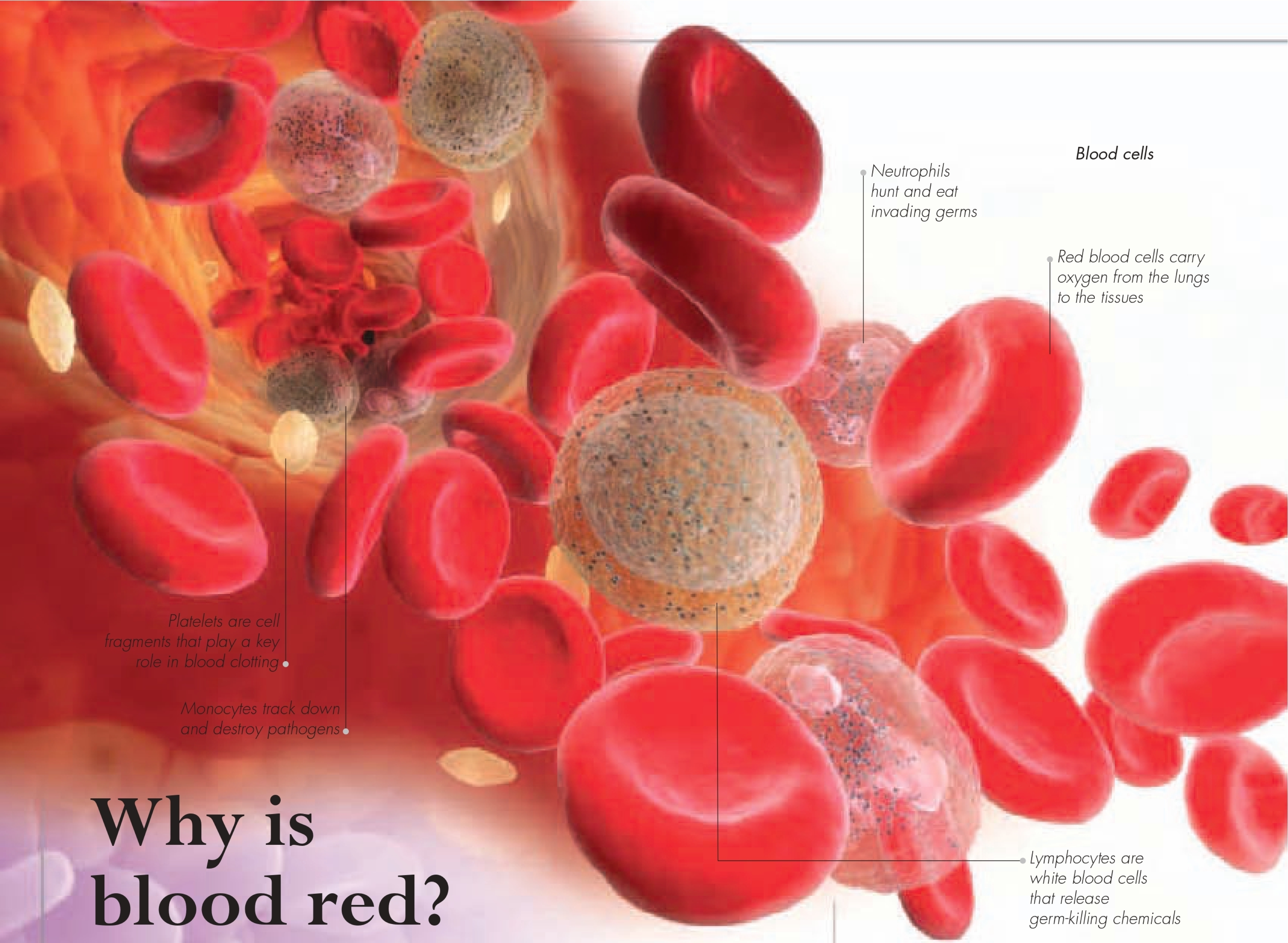
Can we smell danger?

As well as helping you enjoy delicious food or pick up the scent of flowers, your sense of smell has another important role to play. The smell of smoke, for example, warns you that something may be on fire and that you need to take action. Food that looks alright but smells terrible should put you off eating it in case it is poisonous.

More Facts

- People who work as perfumers have a "super sense" of smell that enable them to identify and distinguish between subtle fragrances.
- Other people with smell and taste "super senses" are employed as tea, wine, or food tasters. They are born with this exceptional ability.
- Your millions of smell receptors can detect more than 10,000 different smells, but your taste buds can detect just five different tastes.
- Some scents can be detected at very low concentrations, including methyl mercaptan – the chemical added to odourless natural gas to make it smell.

PUMPING BLOOD



Why is blood red?

Your body's cells need a constant supply of food, oxygen, and other essentials, as well as a prompt removal of wastes, to stay alive. Blood provides this delivery and disposal service as it flows around the body. Billions of oxygen-carrying red blood cells give blood its red colour. Blood also contains white blood cells that defend your body against invading pathogens or germs.

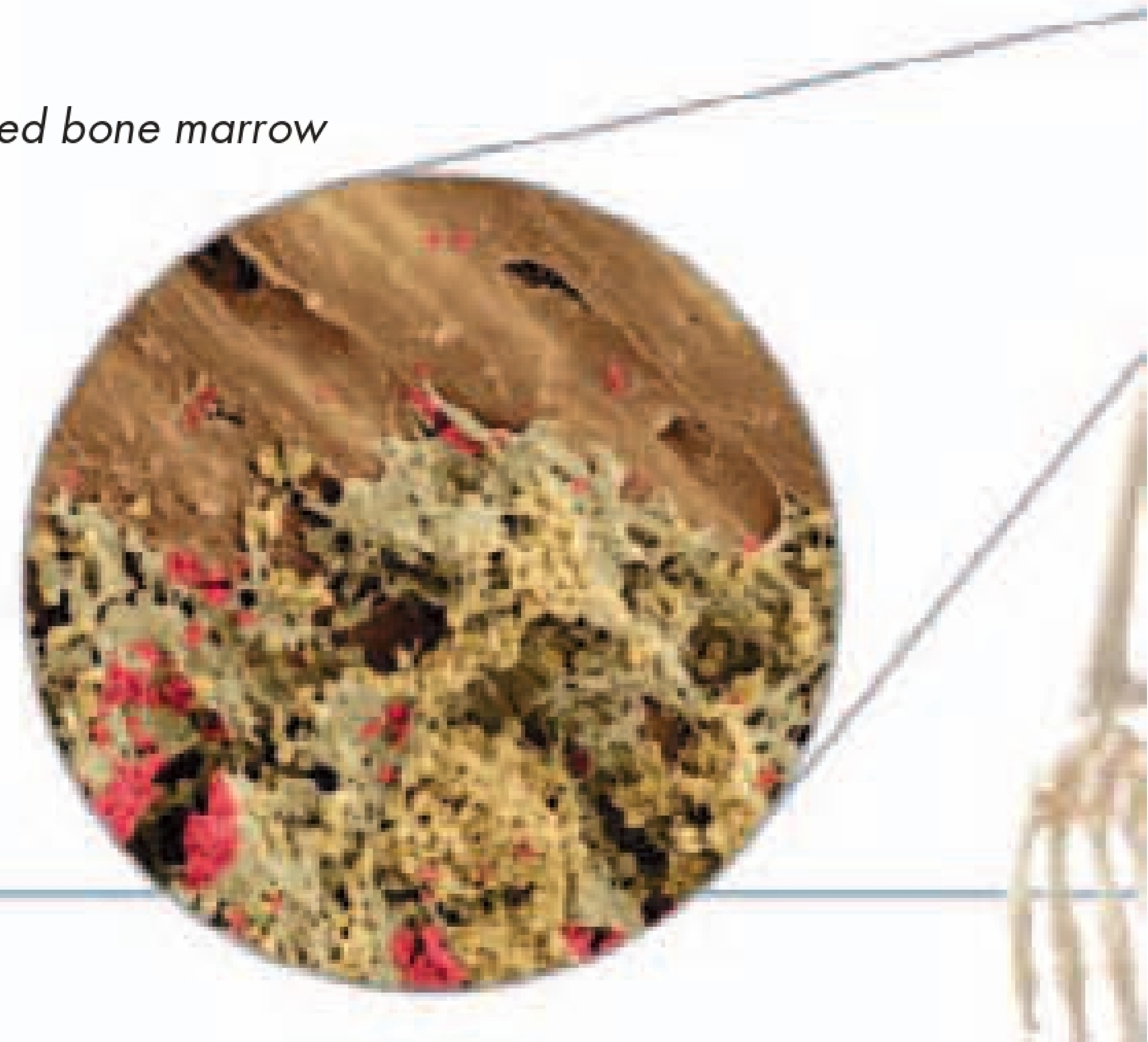
Q What is blood made up of?

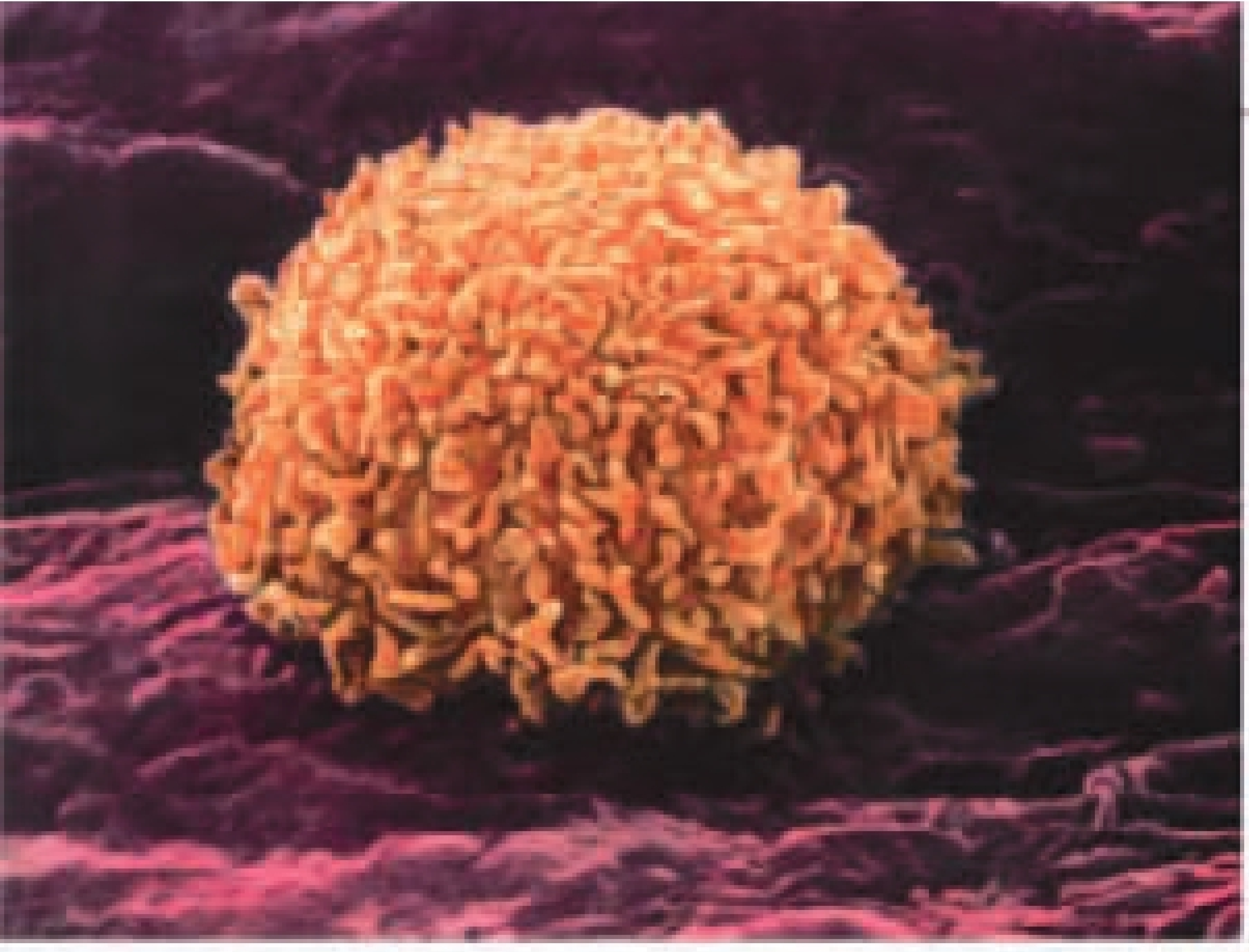
A If a tube full of blood is spun at high speed in a centrifuge, its different parts separate out. Blood cells and platelets sink to the bottom. At the top is yellowish plasma, the liquid in which blood cells normally float. Plasma consists of water and more than 100 dissolved substances including nutrients, wastes, and hormones.

Q Where are blood cells made?

A Bones contain a jelly-like material called bone marrow. Adults have two types: yellow bone marrow, found in long bones, stores fat; red bone marrow, found mainly in flat bones, produces all types of blood cells including platelets. The bones that contain red marrow are coloured pink on this skeleton. In babies, all bone marrow is red.

Red bone marrow

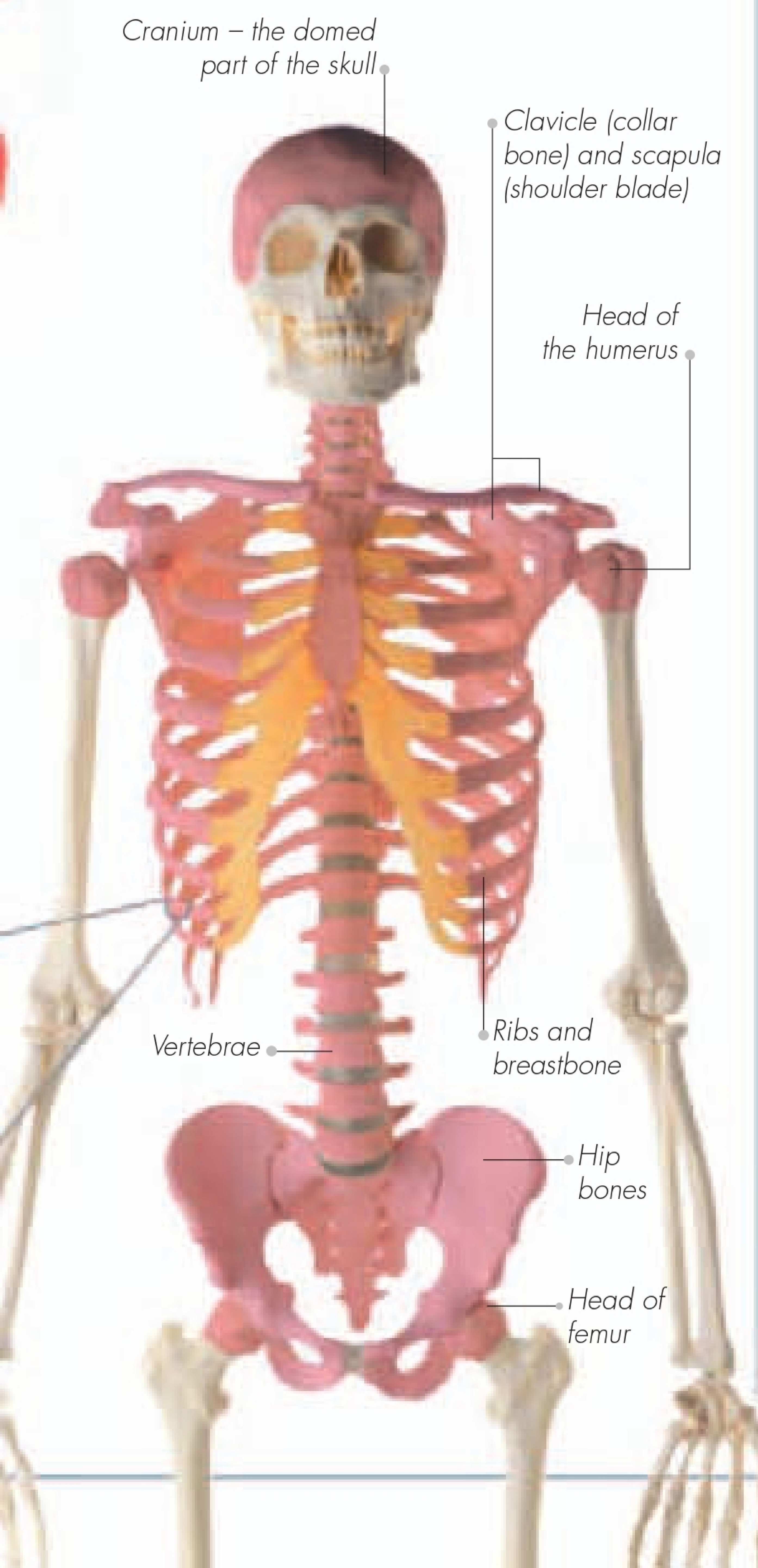




White blood cell

Q Are white blood cells really white?

A This neutrophil has been coloured to make it stand out but in real life it is transparent, like other types of white blood cells. They are called "white" because they are not red and also because they form a thin, white layer when blood is spun in a centrifuge tube. Like other white blood cells, neutrophils protect the body against infection.



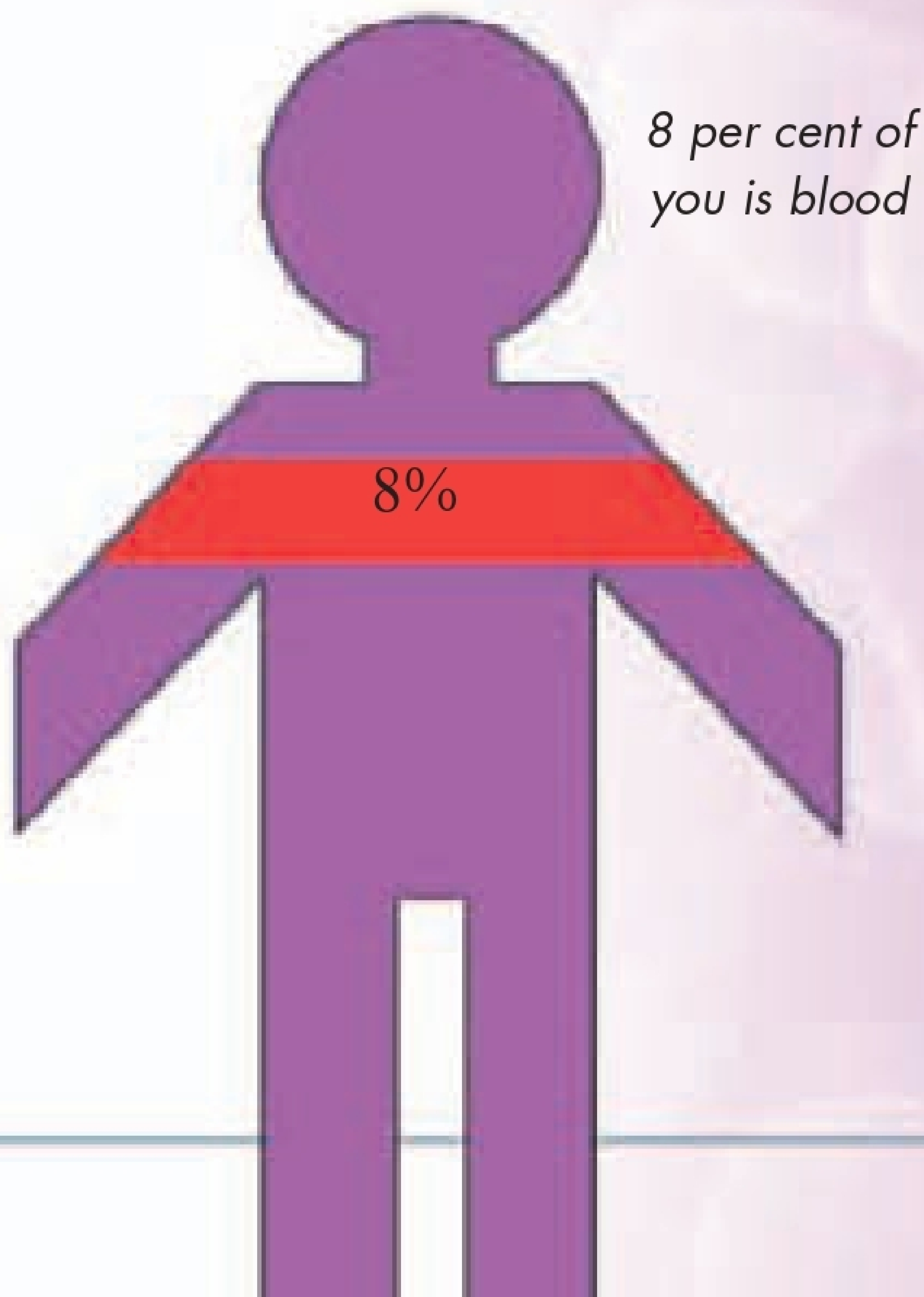
Transfusion bags containing blood

Q Why are there different blood groups?

A Your red blood cells carry one, both, or neither of two tiny markers called A and B. Whether you do or don't have these markers determines whether you belong to blood group A, B, AB, or O. To avoid problems during blood transfusions (transfers), a person should receive blood from someone with the same blood group.

Q How much blood do I have?

A If all the blood were drained out of your body you would be about 8 per cent lighter in weight. In adults, this percentage amounts to between 4 and 5 litres (7 and 8.8 pints) of blood in women and, because they are bigger on average, 5 to 6 litres (8.8 to 10.5 pints) in men. The volume of blood in your body is controlled by your kidneys.



More Facts

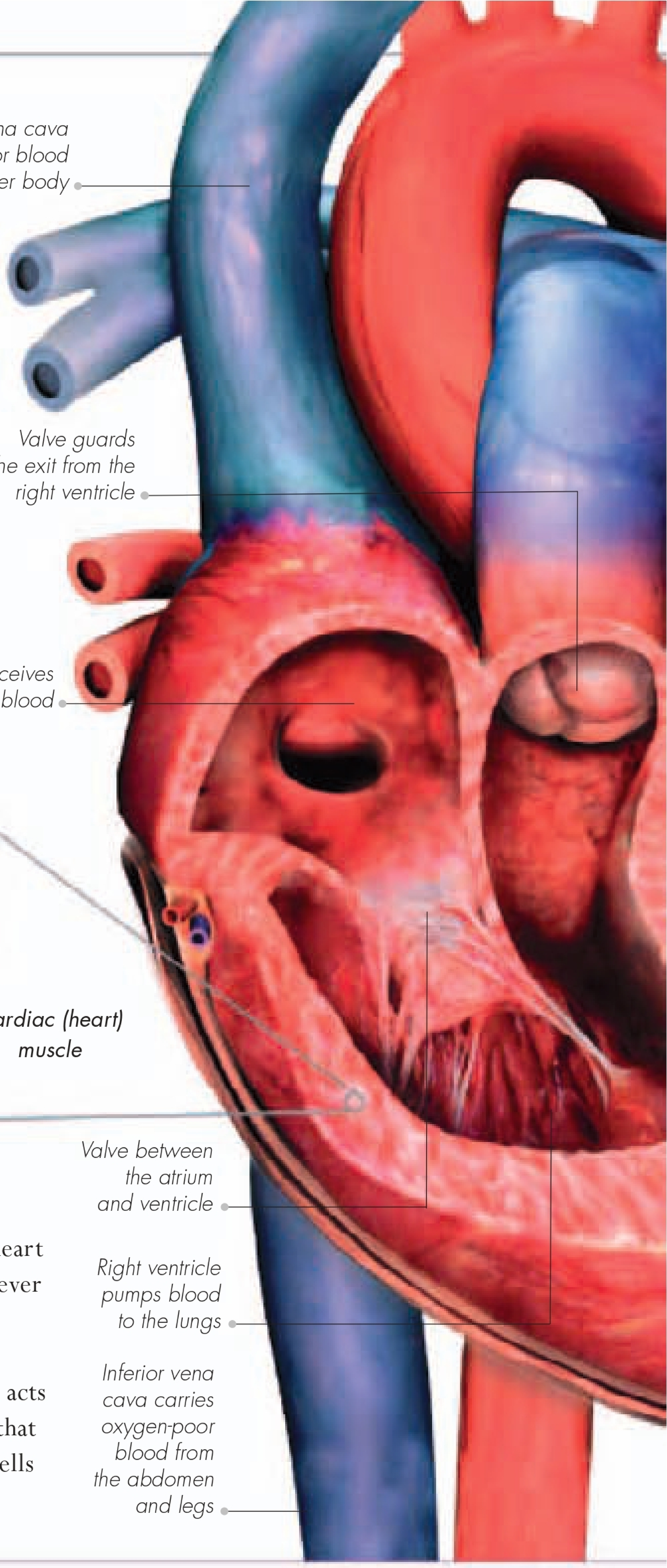
- A single tiny drop of blood contains 250 million red blood cells, 375,000 white blood cells, and 16 million platelets.
- Red blood cells have no nucleus, and a lifespan of 120 days. Two million new red blood cells are made by bone marrow every second.

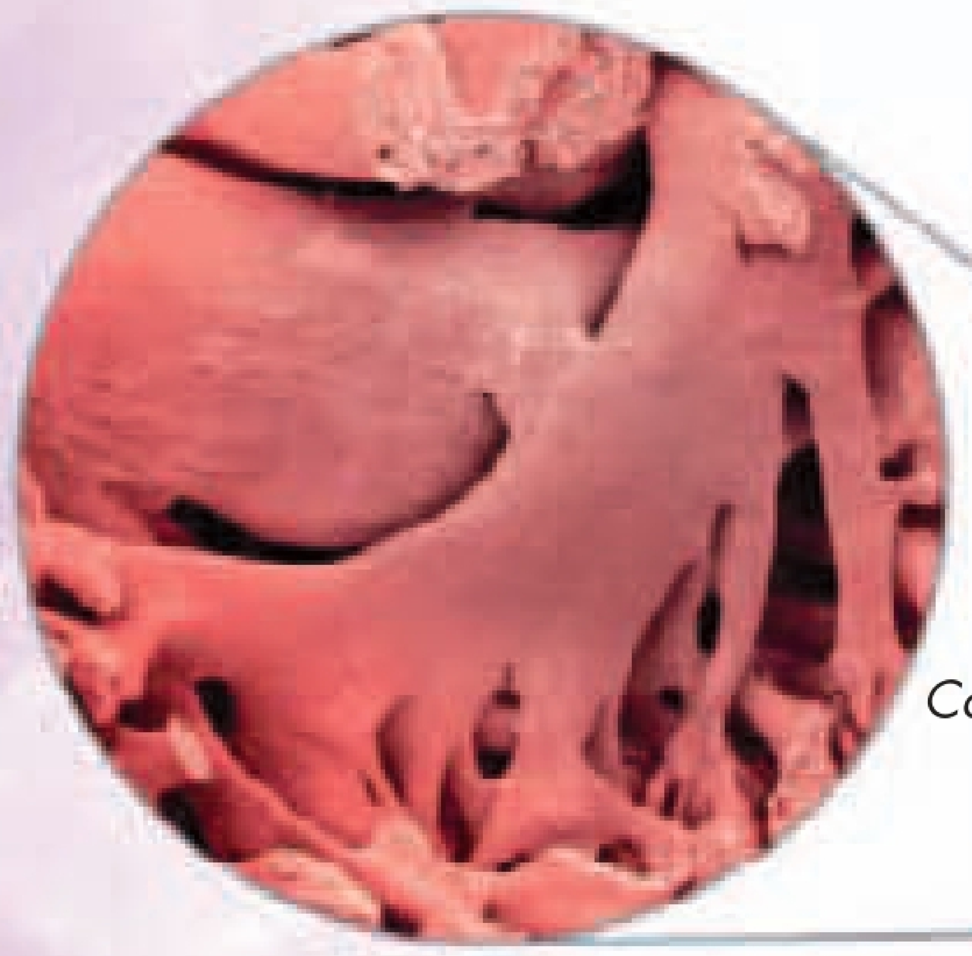
Rosy periwinkle

- Leukaemia is a disease, sometimes fatal, where too many abnormal white blood cells are produced. Drugs extracted from the rosy periwinkle, a rainforest plant, have been used to successfully treat leukaemia.
- Red blood cells contain haemoglobin, a red-coloured protein that carries oxygen. A single cell contains 250 million haemoglobin molecules.

How fast does my heart beat?

At the core of your body's blood transport system is a muscular pump – the heart. The heart has two sides – left and right – each with an upper and lower chamber – the atrium and ventricle. The heart beats about 70 times a minute to pump blood to your cells, speeding up when necessary to meet increased demand. Over an average lifetime, the heart beats more than 2.5 billion times without taking a rest.



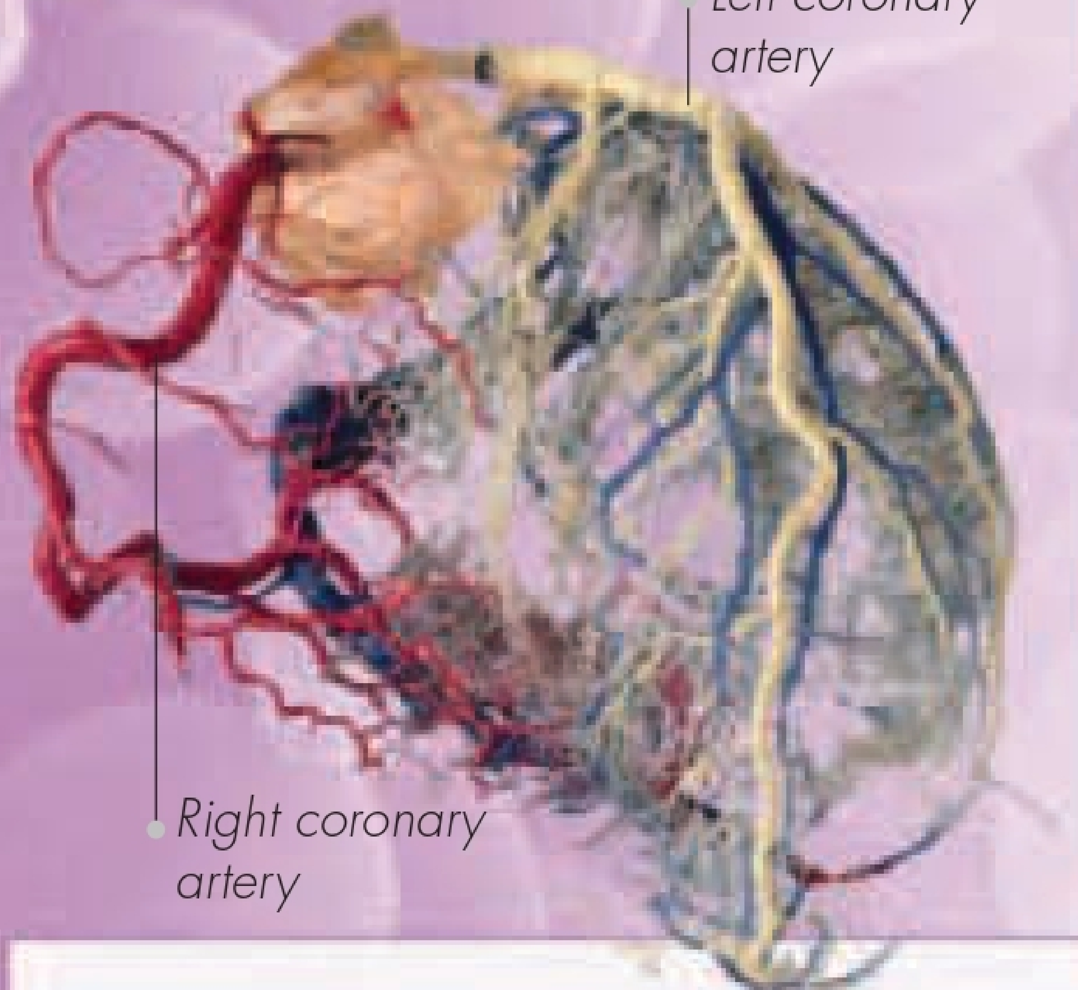


Cardiac (heart) muscle

Q Does the heart have its own blood supply?

A The muscular wall of your heart needs an uninterrupted supply of fuel and oxygen to keep it beating. But it can't get those supplies from the blood that gushes through its chambers. Instead it has its own special supply: two coronary arteries, shown here in this cast, branch repeatedly to carry oxygen-rich blood throughout the heart's wall.

Cast of coronary arteries



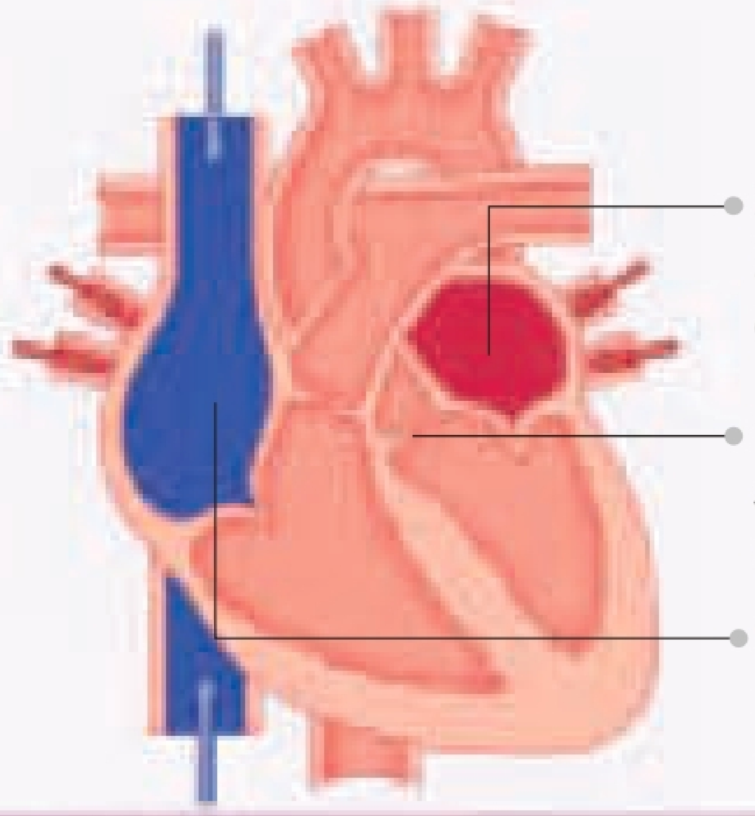
Q What's special about heart muscle?

A In a lifetime of beating, your heart never takes a break. Cardiac muscle never tires, contracting regularly and automatically to pump blood. A tiny section of the wall of the right atrium acts as a "pacemaker". It sends out signals that make the network of cardiac muscle cells contract at the same rate.

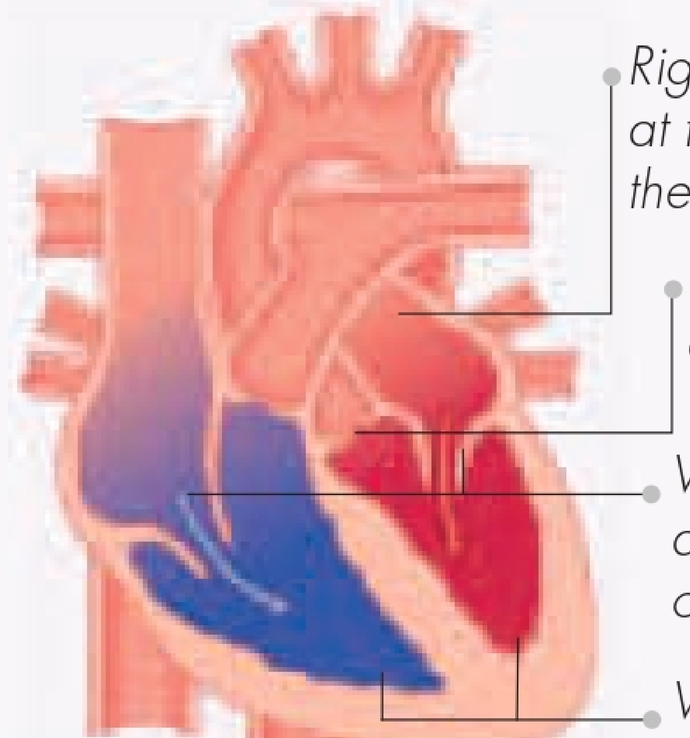
What happens during a heartbeat?

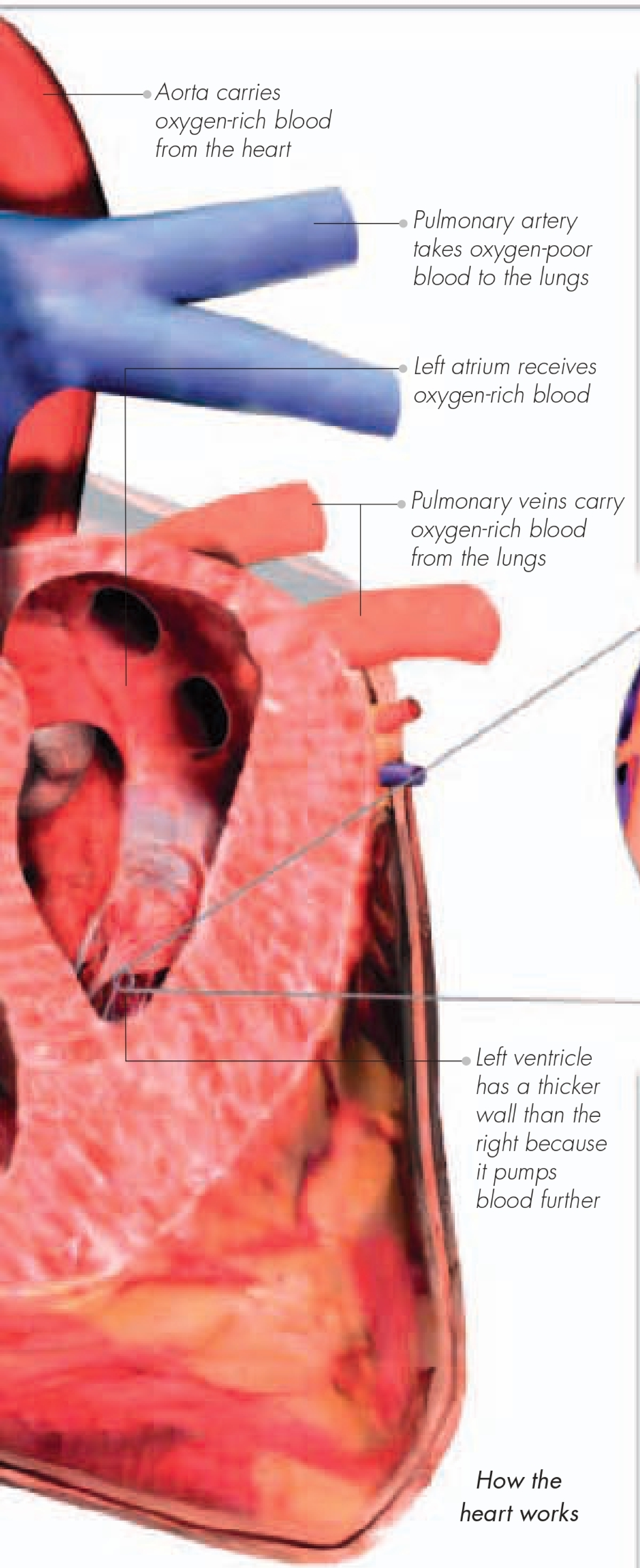
If you listen to, or feel, your heart beating, every heartbeat probably feels like a single event. In fact, each one is made up of three separate, precisely timed stages. Electrical signals spread through the heart's muscular wall ensuring that first the atria and then the ventricles contract to pump blood through and out of the heart. Valves ensure that blood flow is always in the same direction.

1 *Your heart's muscular wall is relaxed and blood from the lungs and the body flows, respectively, into the left and right atria.*



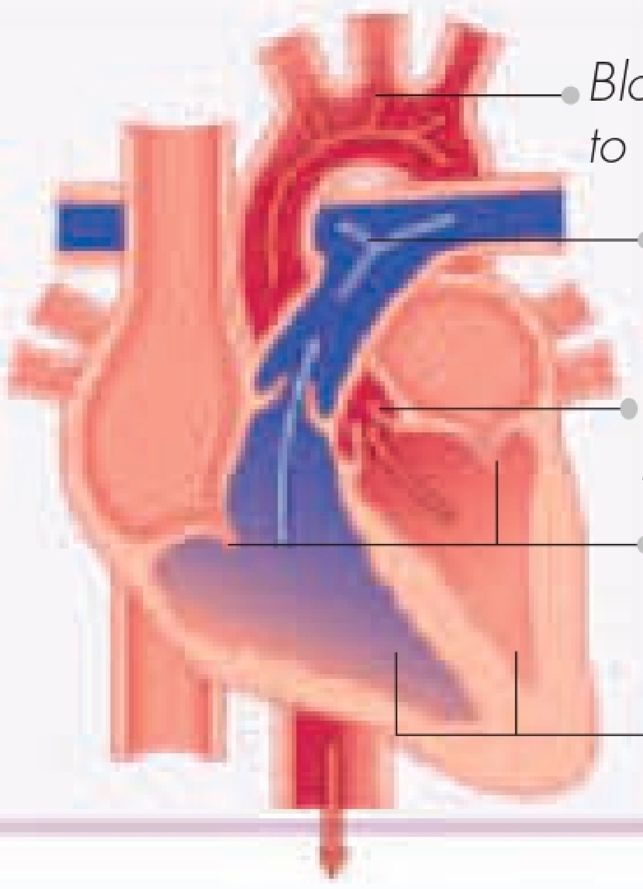
2 *Left and right atria contract together, forcing blood through the valves that separate them from their ventricles. Other valves remain closed.*





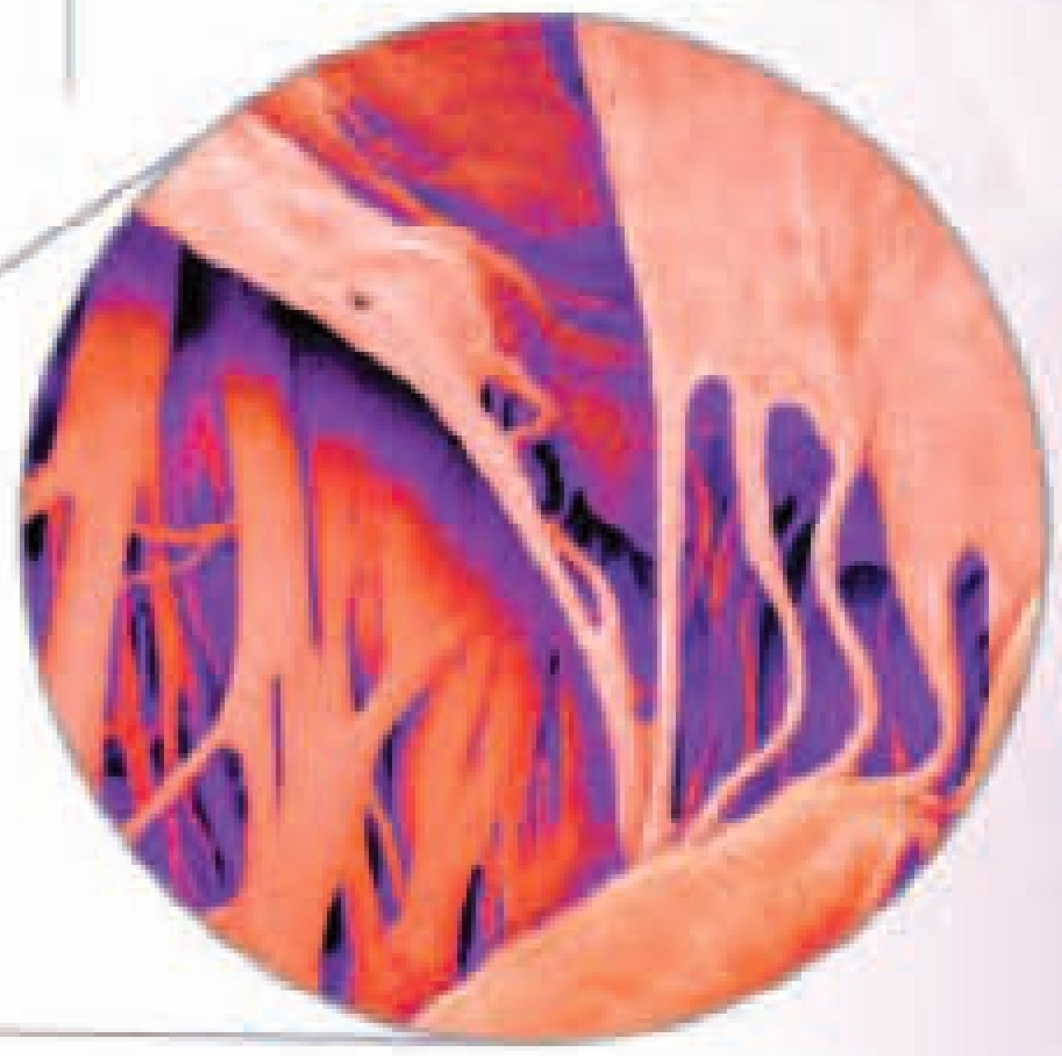
How the heart works

3 The two ventricles contract together, pushing blood to the lungs and body. Valves between atria and ventricles close to prevent backflow.



Q Do heartstrings really exist?

A If someone "tugs at your heartstrings" it means you feel sympathy for them. It's just an expression, but there are also real heartstrings. When your ventricles contract, these cords tug at the valves between the atria and ventricles. This stops the valves turning inside out like umbrellas in a gale.



Heartstrings

Q Why does my heart beat faster when I run?

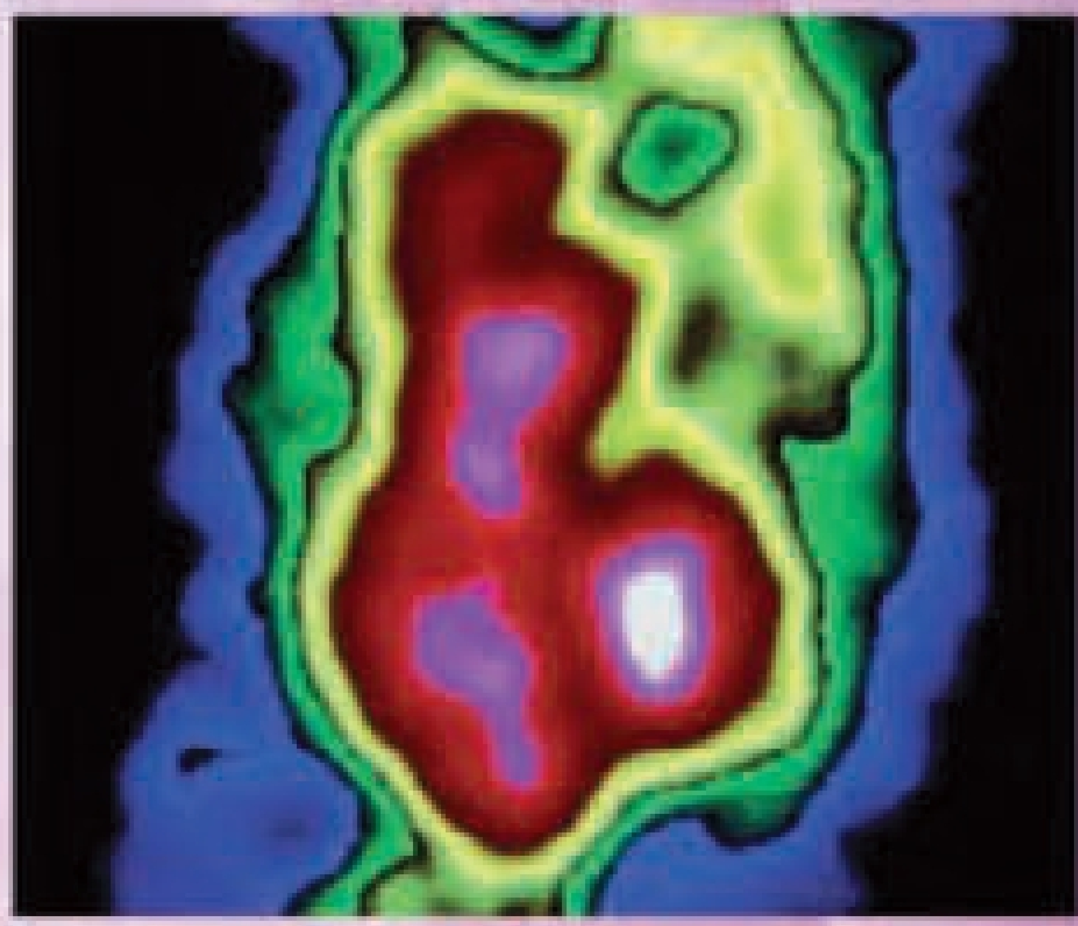
A Your muscles need energy to move you. This energy is generated using glucose and oxygen, which are delivered by the blood. The more active you are and the more strenuous the exercise, the harder your muscles work and the more energy they need. To supply this demand, your heart beats faster to pump more blood to your muscles to meet their need for extra glucose and oxygen.

Strenuous exercise

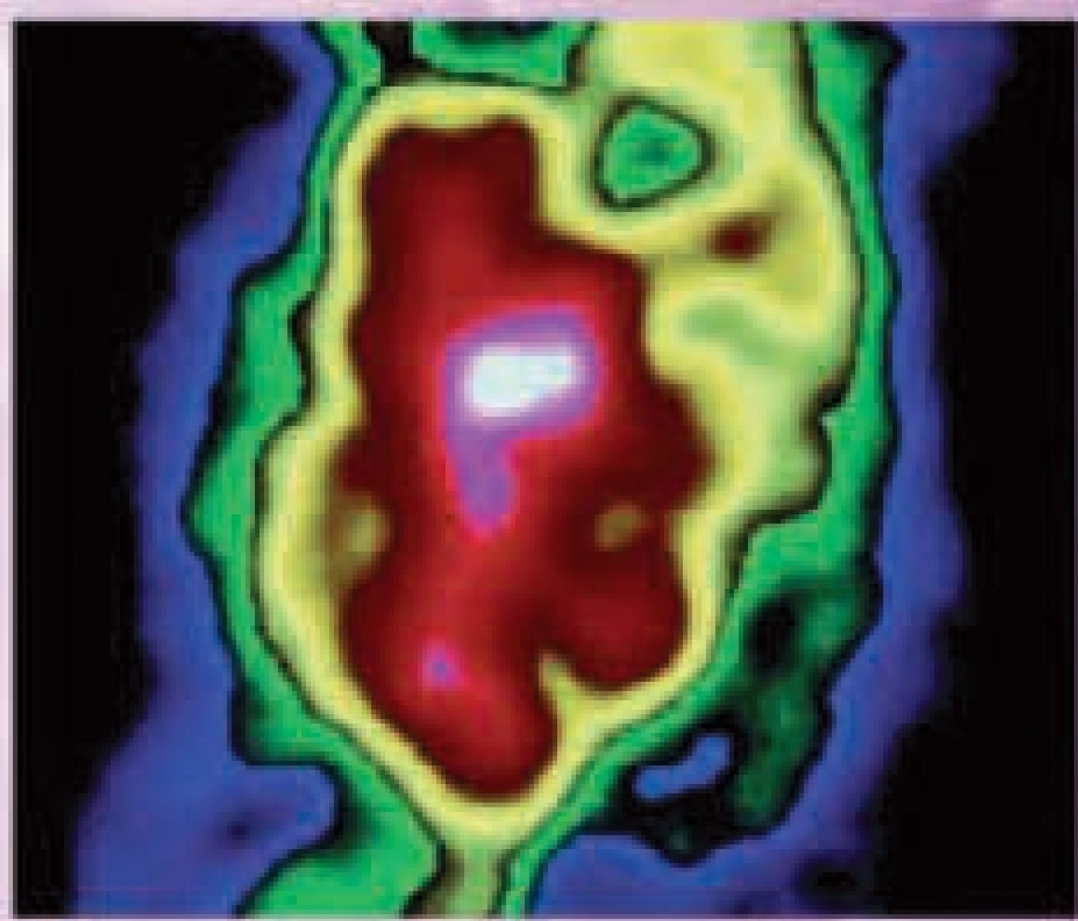
Q What do doctors hear through a stethoscope?

A Every time your heart beats it produces sounds. A short "dup" sound is created when the valves guarding the heart's exits close as the ventricles relax. A longer "lub" sound is made when the ventricles contract and valves between atria and ventricles slam shut. By listening to heart sounds, doctors can check whether valves are doing their job properly.

Scan of relaxed heart

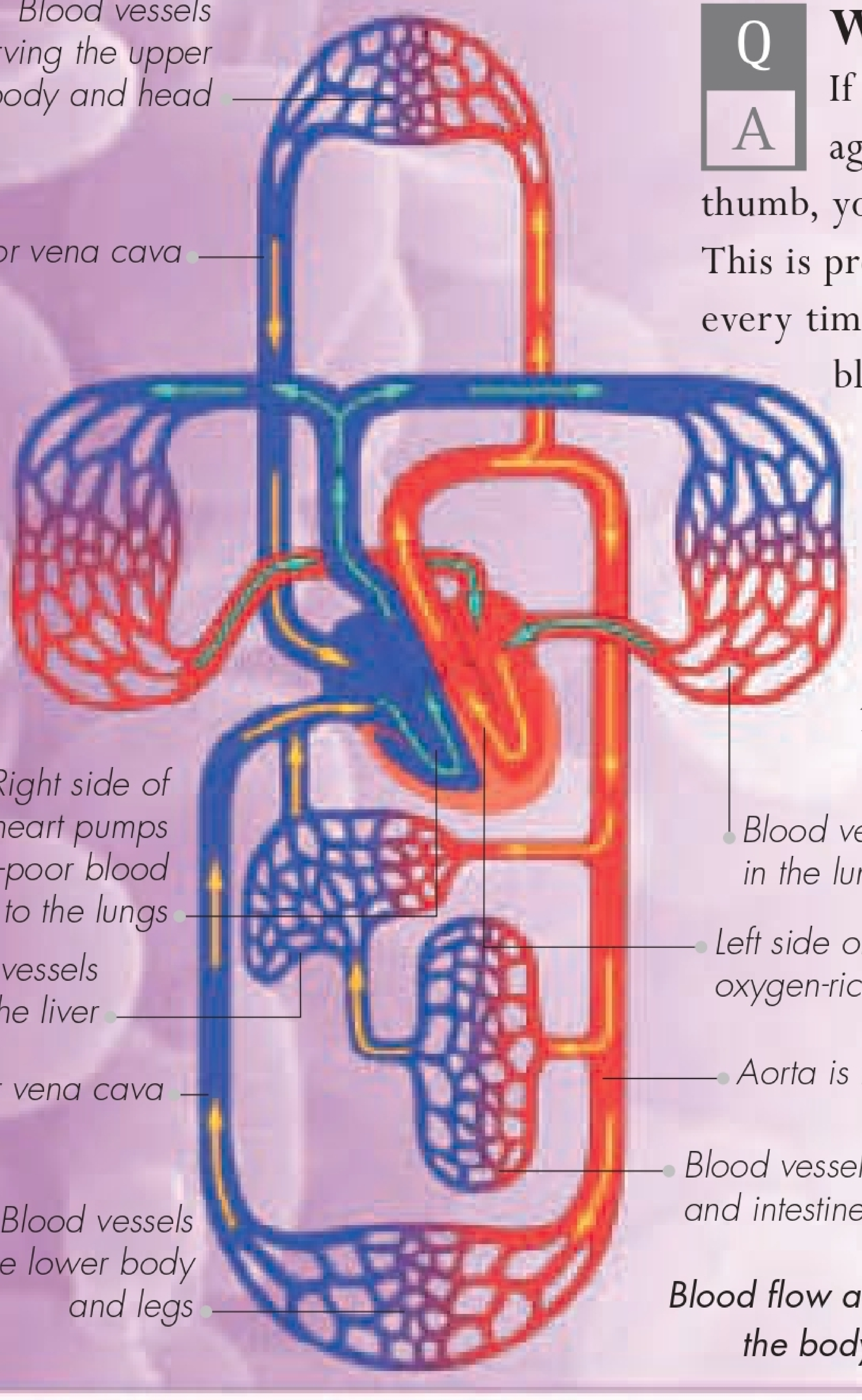


Scan of contracted heart



What journey does my blood take?

Pumped by the heart, blood circulates in one direction around the body to deliver supplies to all body cells. This circulatory system has two "loops". One carries oxygen-poor blood (blue) from the heart to the lungs to pick up oxygen. The other sends out oxygen-rich blood (red) to the tissues through the aorta, and returns oxygen-poor blood to the heart through the large vena cava veins.

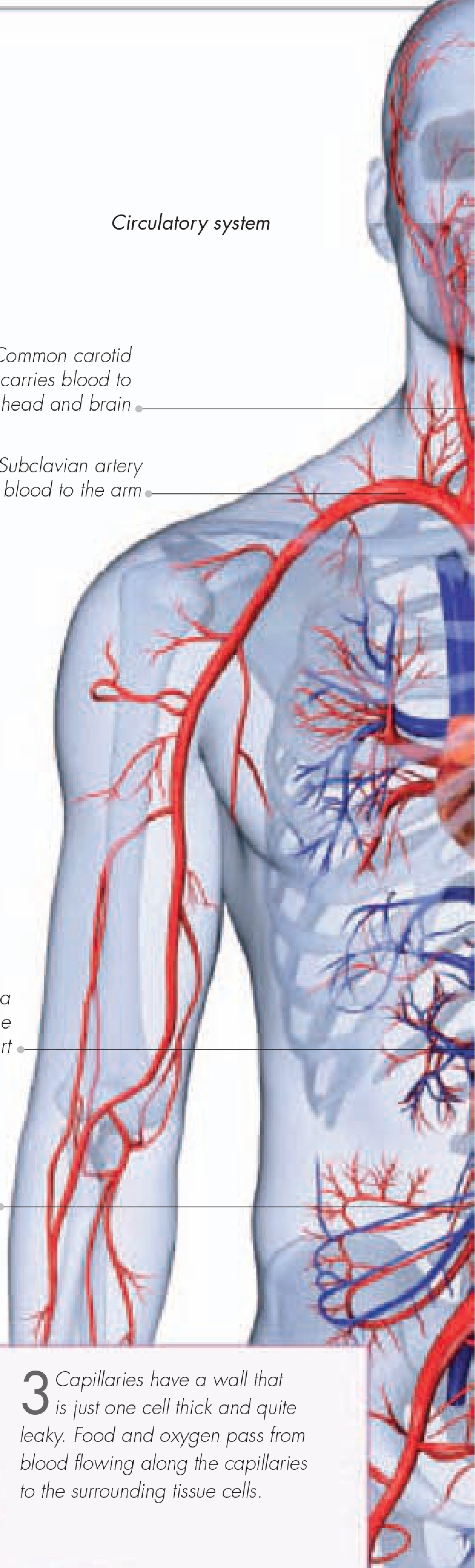


Blood flow around the body

Q What is a pulse?

A If you hold the tips of two fingers against your wrist, just below your thumb, you should feel a regular "pulse". This is produced by an artery expanding every time your heart beats and forcing blood along it. You have a vast network of blood vessels, made up of arteries (red), veins (blue), and tiny capillaries. Altogether these blood vessels stretch for more than 100,000 km (60,000 miles).

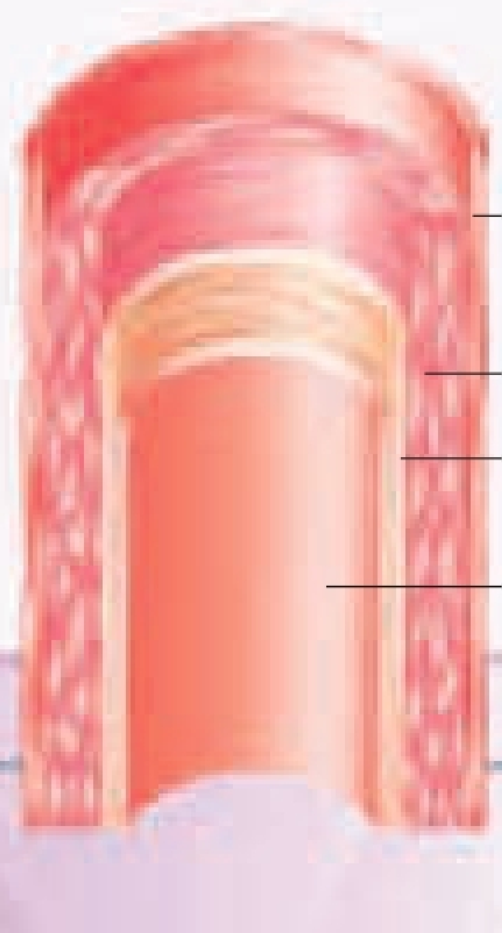
Circulatory system



What is the difference between arteries and veins?

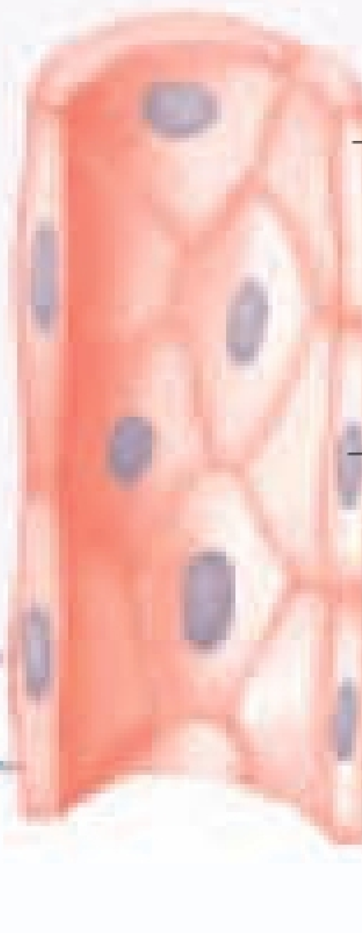
There are three types of blood vessels in your body – arteries, veins, and capillaries – each with their own distinct structure. Arteries and veins are linked by a network of capillaries that pass through all body tissues.

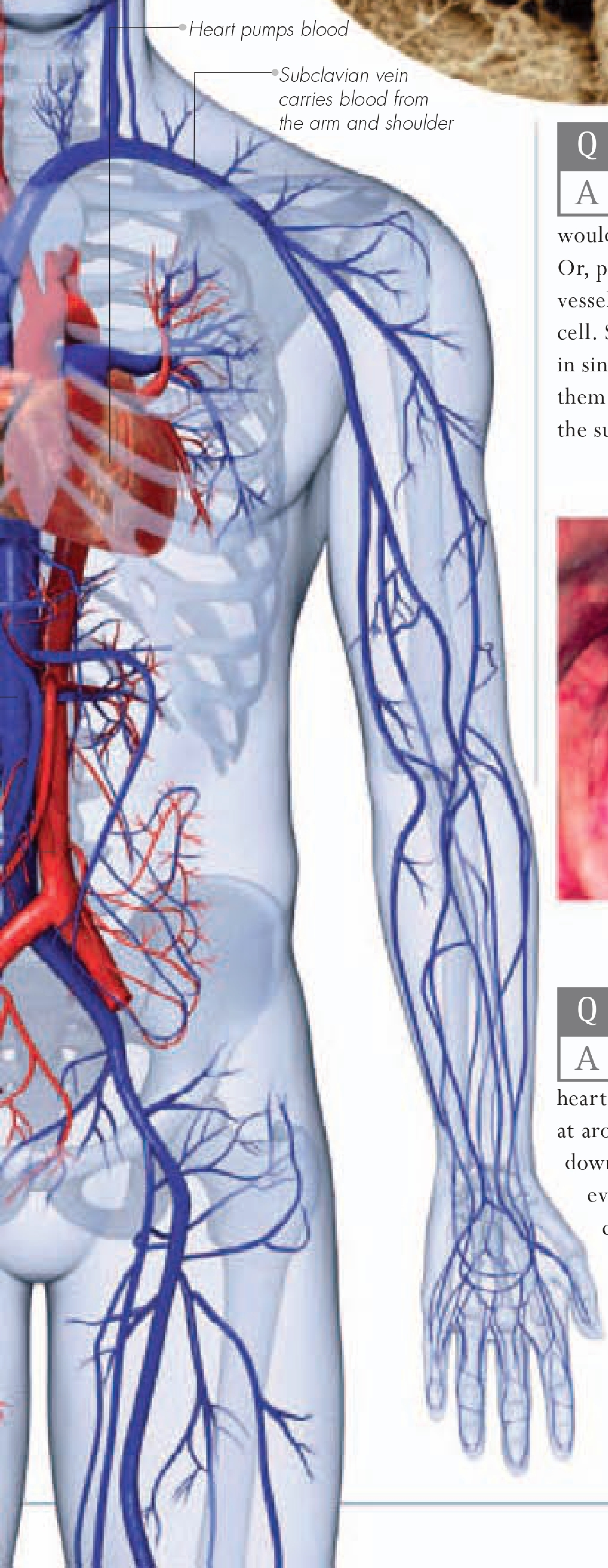
1 *Arteries carry oxygen-rich blood from the heart to the tissues. They have a thick wall that is both muscular and elastic to withstand the high blood pressure created when the heart beats.*



2 *Veins have thin walls and carry oxygen-poor blood under low pressure from the tissues towards the heart. Valves inside veins prevent blood from flowing backwards.*

3 *Capillaries have a wall that is just one cell thick and quite leaky. Food and oxygen pass from blood flowing along the capillaries to the surrounding tissue cells.*

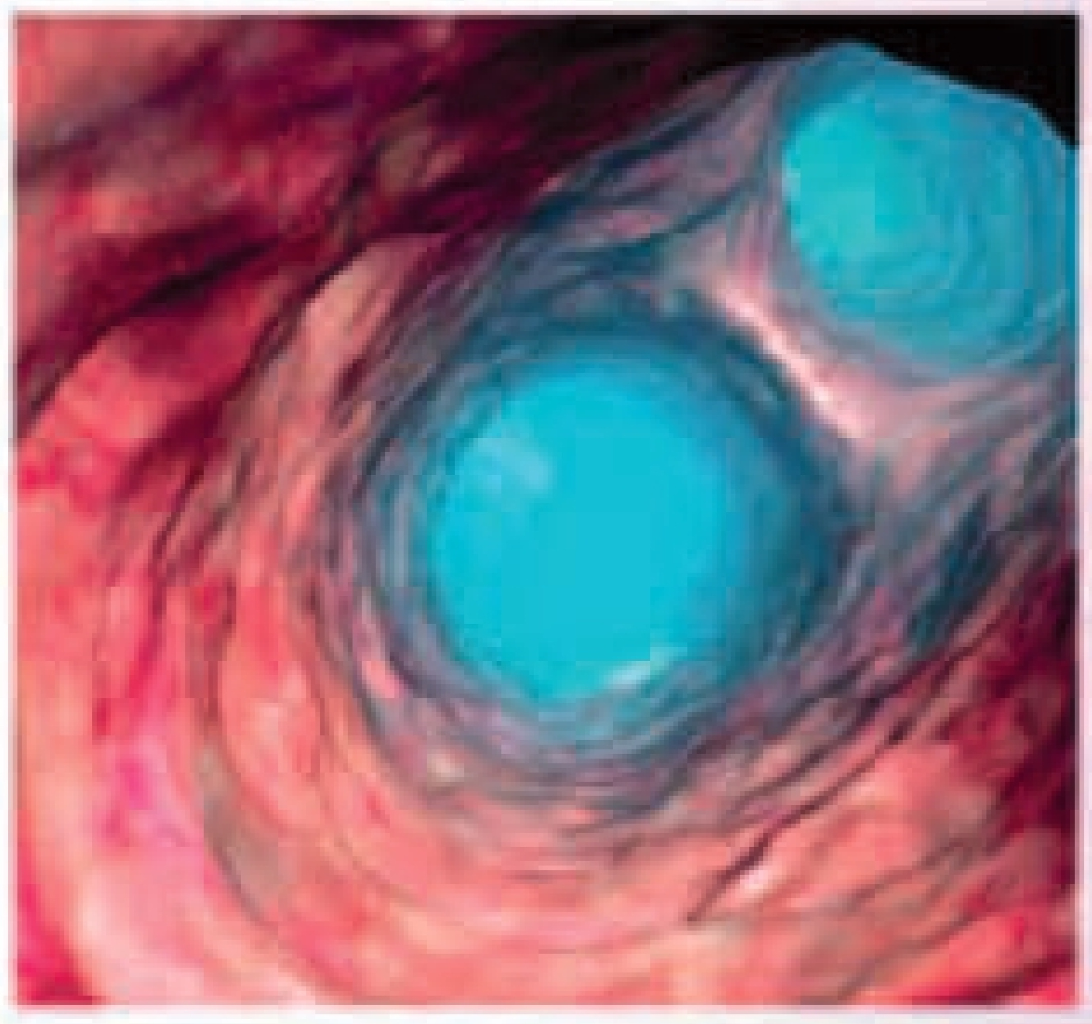




Cut-open capillary

Q How wide are the capillaries?

A Ten capillaries placed side by side would be as thick as a hair from your head. Or, put another way, these tiniest of blood vessels are just wider than a red blood cell. Since red blood cells have to travel in single file along capillaries, it gives them more time to release oxygen into the surrounding tissues.



Inside an artery

Q How fast does my blood flow?

A When blood emerges from the heart, it races along the largest arteries at around 1 m (3 ft) per second. It slows down in smaller arteries and becomes even more sluggish as it travels along capillaries and veins. That said, a red blood cell takes, on average, under a minute to get around the circulatory circuit. The slick lining of blood vessels ensures that blood flows smoothly.

Q Why do people get frostbite?

A When it's cold, the blood vessels supplying your skin temporarily get narrower so that less blood flows through them. This reduces heat loss through the skin, especially from exposed parts such as the fingers. But if the body is exposed to freezing conditions for long periods, narrowed blood vessels starve skin cells of vital supplies, resulting in painful frostbite.

Blood vessels of a hand

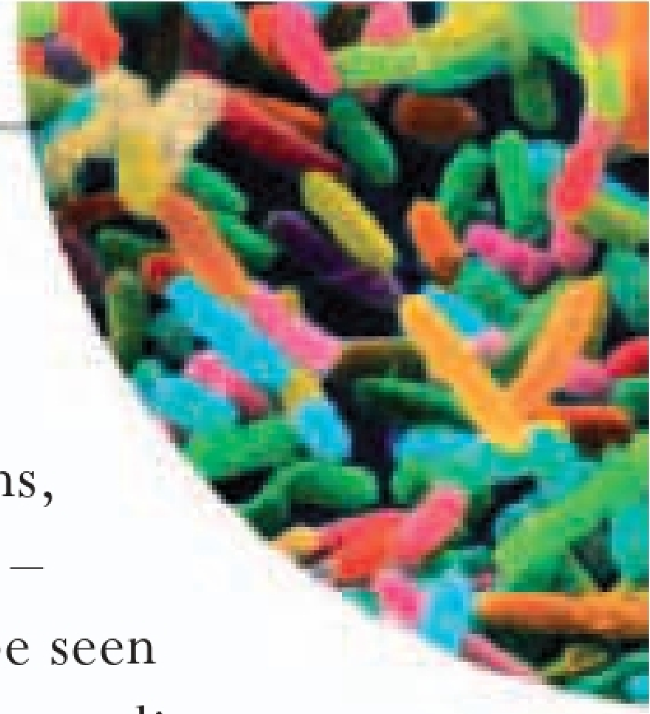
Q What is blood pressure?

A It may have a long name but this machine (below) has a straightforward role, measuring your blood pressure. This is the pressure, or "push", on an artery's wall, produced when your heart beats. Blood pressure provides the driving force that keeps blood moving around your body. But if it is too high for long periods it can cause health problems.

Sphygmomanometer

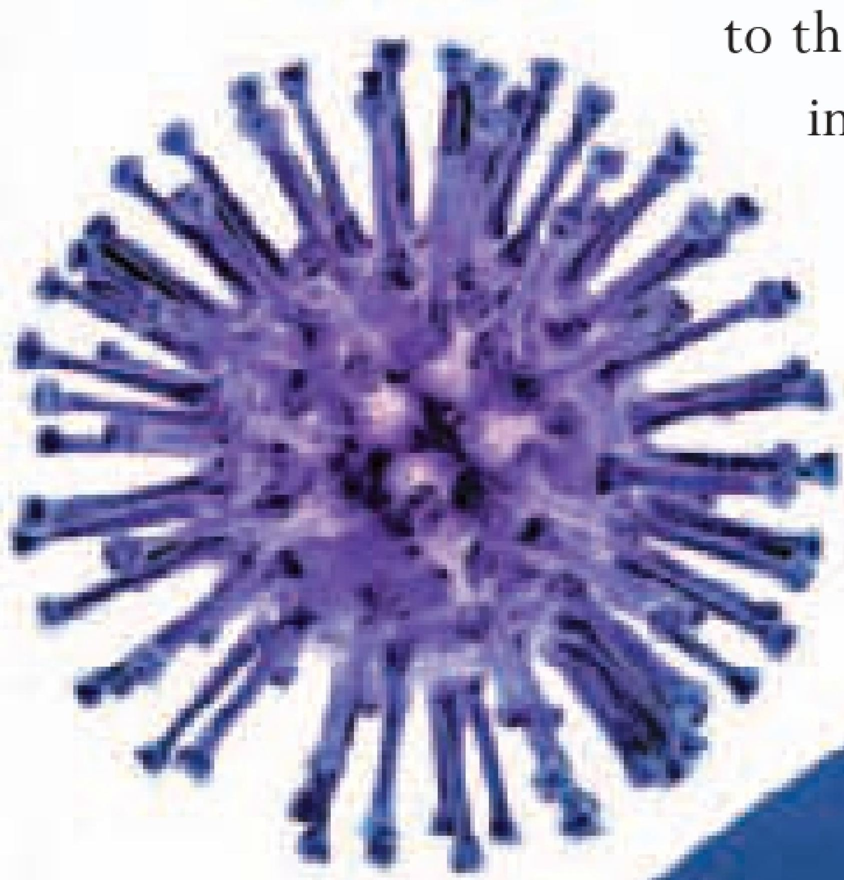
How does my body protect itself?

You are constantly exposed to germs that will make you ill if they get inside your body. Various defence mechanisms stop this from happening. Your skin, for example, is a germ-proof barrier. If germs do get in, they are destroyed by macrophages and lymphocytes – white blood cells found in your blood – and in your body's drainage network, the lymphatic system (below).

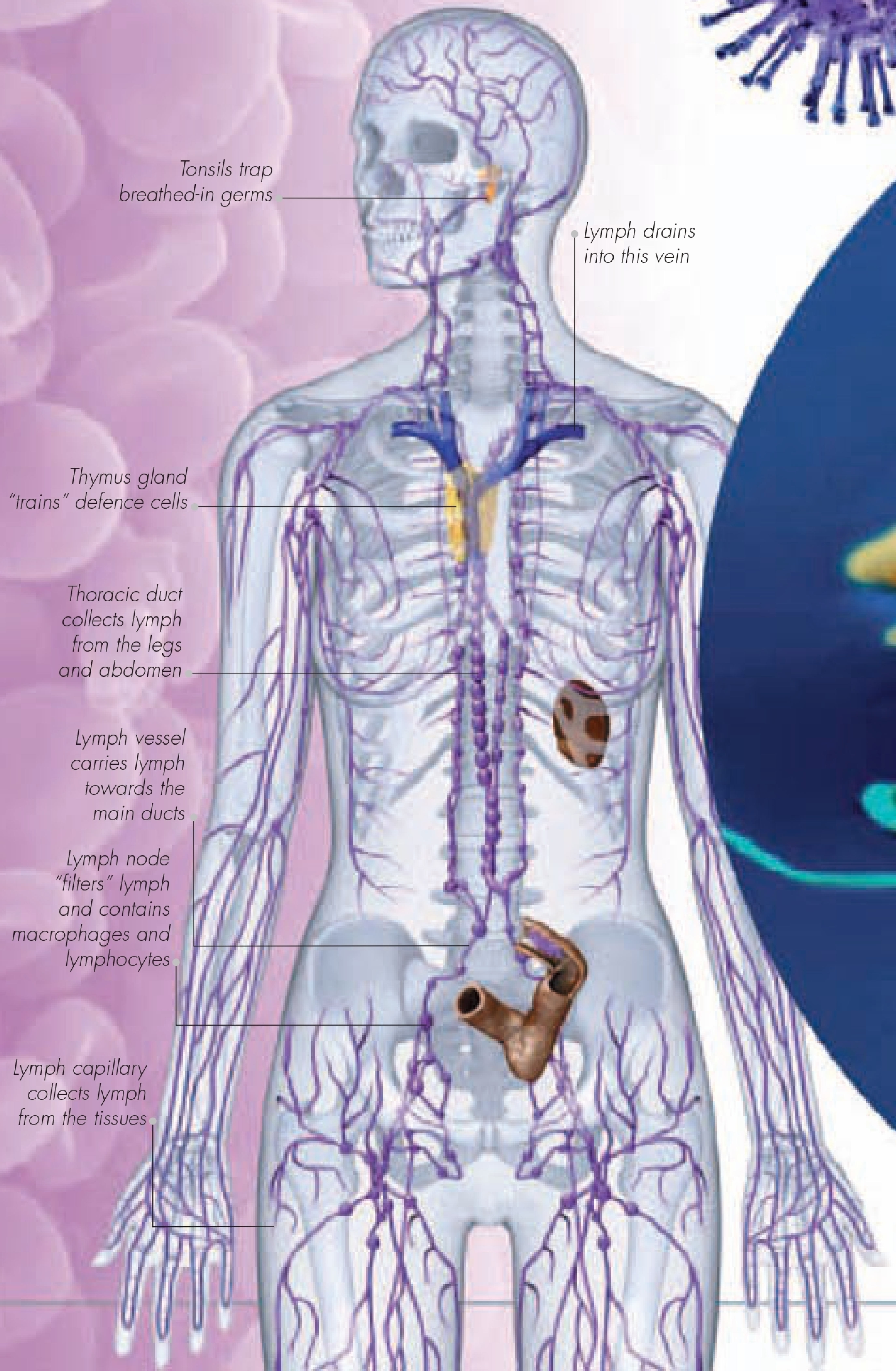


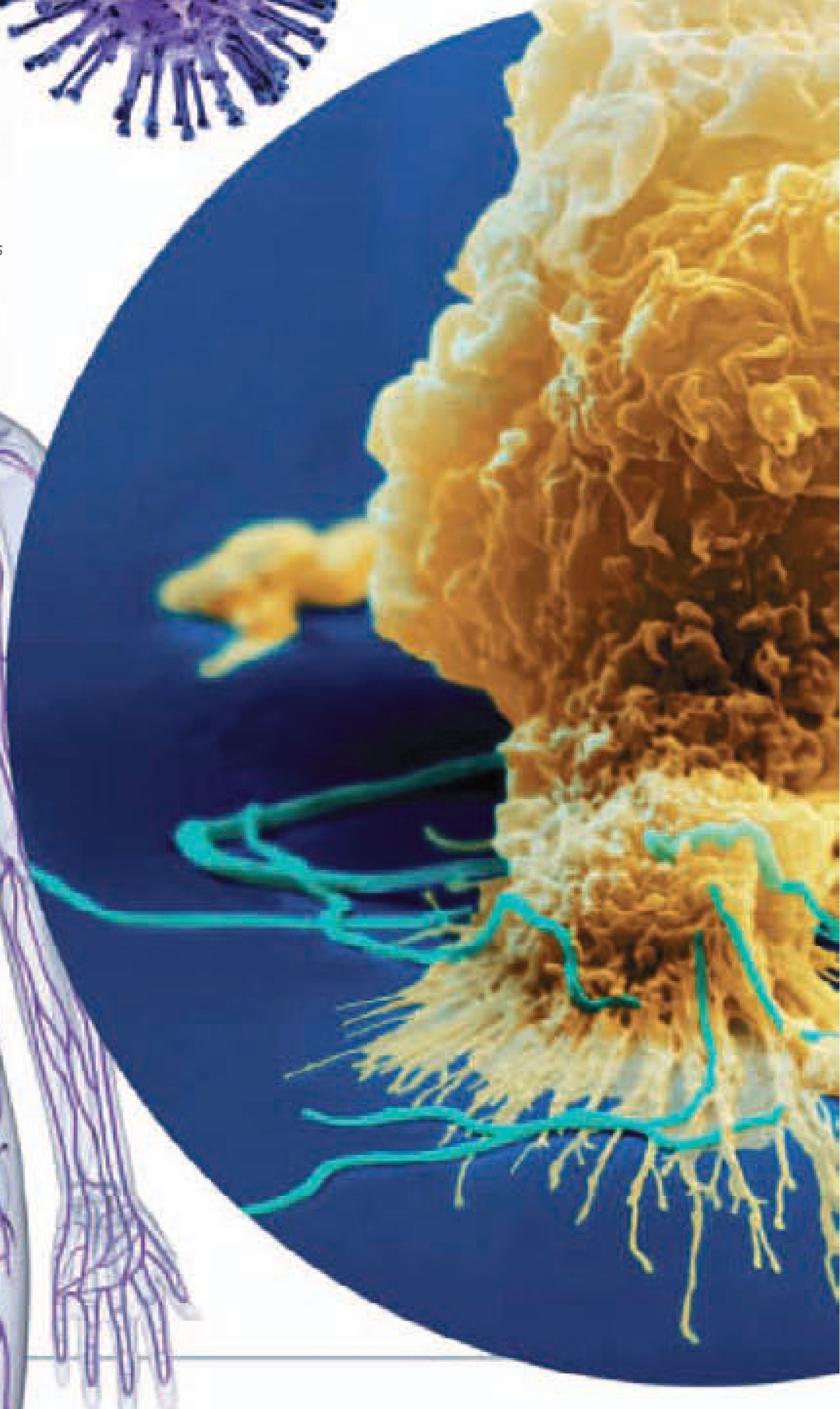
Q What are germs?

A Also called pathogens, germs are micro-organisms – living things that can only be seen using a microscope – that cause disease. That is, they stop your body from working normally. Germs include the viruses that give you the flu or a cold, and the bacteria that cause stomach upsets. Left to their own devices they would multiply inside your body and cause great harm.



Flu virus particle



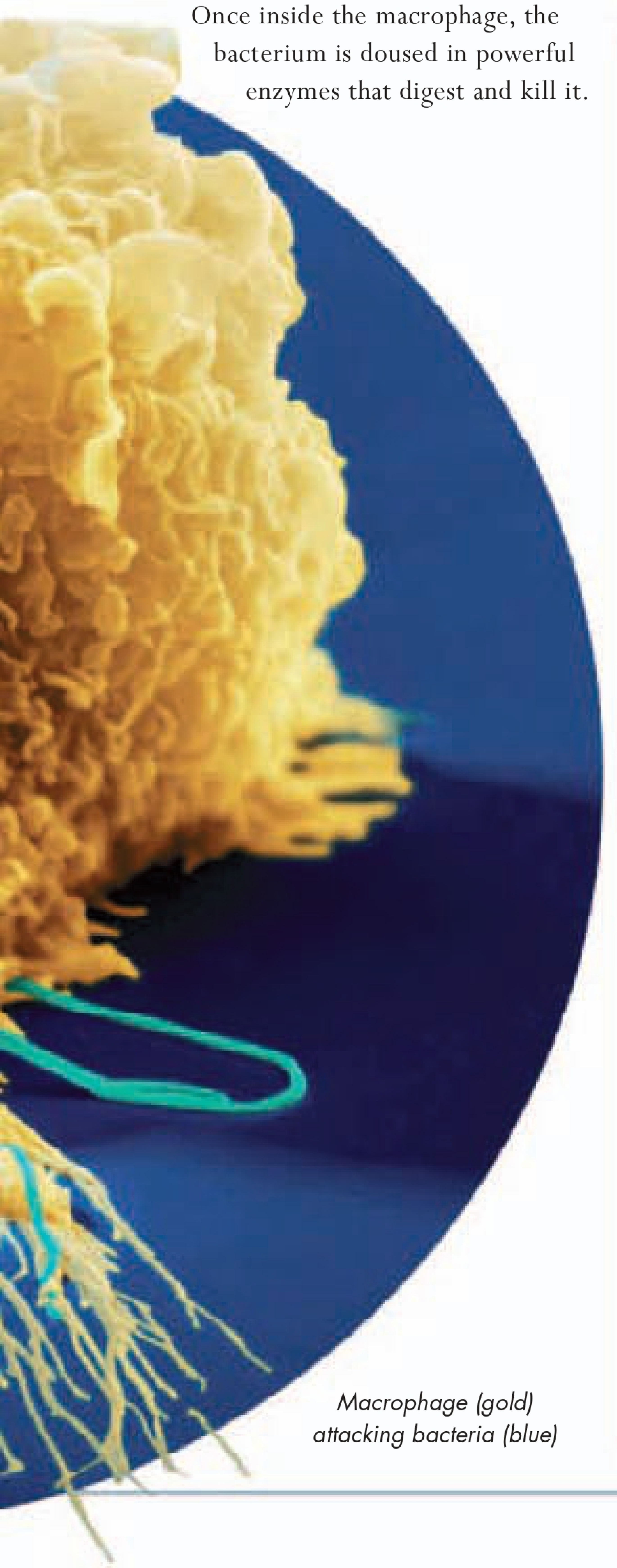


E.coli bacteria

How do white blood cells kill bacteria?

Q

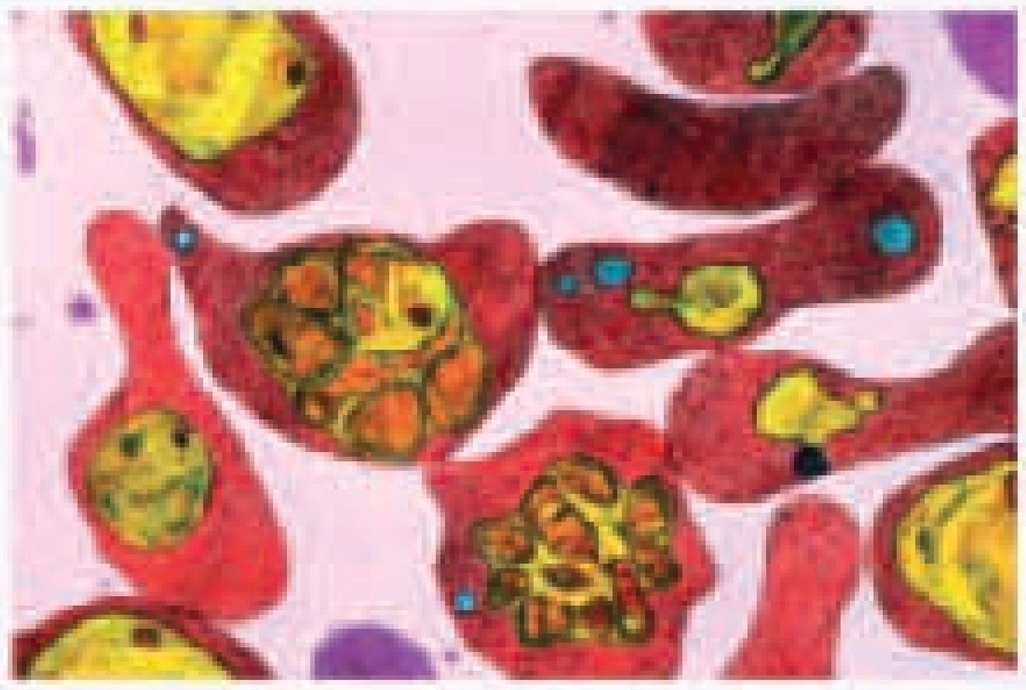
A Macrophages like this one are white blood cells that specialize in destroying bacteria by eating them. This ruthless hunter tracks down invaders by following the chemical trails that they leave behind them. The macrophage then sends out projections that stick to and surround a bacterium, and pulls the germ inside it. Once inside the macrophage, the bacterium is doused in powerful enzymes that digest and kill it.



Macrophage (gold) attacking bacteria (blue)

More Facts

- Protists are single-celled organisms and some of them are germs. Plasmodium, for example, is a protist that causes malaria. Biting mosquitoes spread it from person to person, and it multiplies inside their red blood cells.
- Once you have had a particular disease, your immune system responds much faster to another attack of the same pathogens so you rarely get the same disease twice.



Plasmodium protists inside red blood cells

- Your tears, saliva, and sweat contain germ-killing chemicals, while stomach acid destroys bacteria or viruses that you swallow in food or drink.

Why does a doctor take your temperature?

Q

A Under normal conditions your body's internal temperature is about 37°C (98.6°F). But if you are infected by bacteria or viruses, your body gets hotter, producing a fever. This helps to fight infection because germs cannot multiply and spread at higher temperatures.

Taking a temperature

Does my body remember different germs?

Q

A Your body has an army of powerful defenders. Lymphocytes are a type of white blood cell that "remember" a germ's identity and release disease-fighting chemicals called antibodies to target specific germs. Antibodies do not destroy germs; they bind to their prey and mark them for destruction by macrophages.

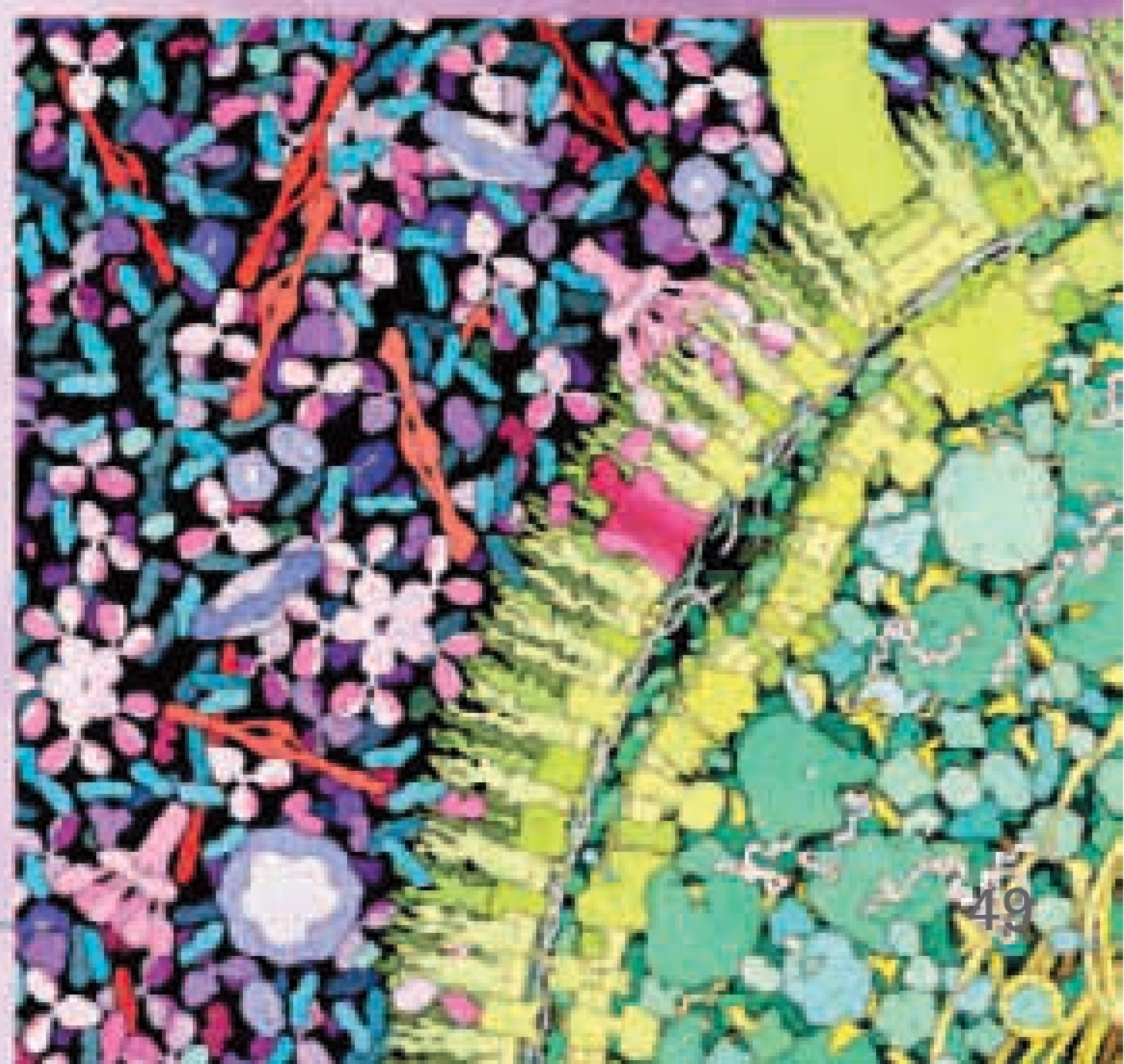
Close-up view of a scab (red)

How does a scab form?

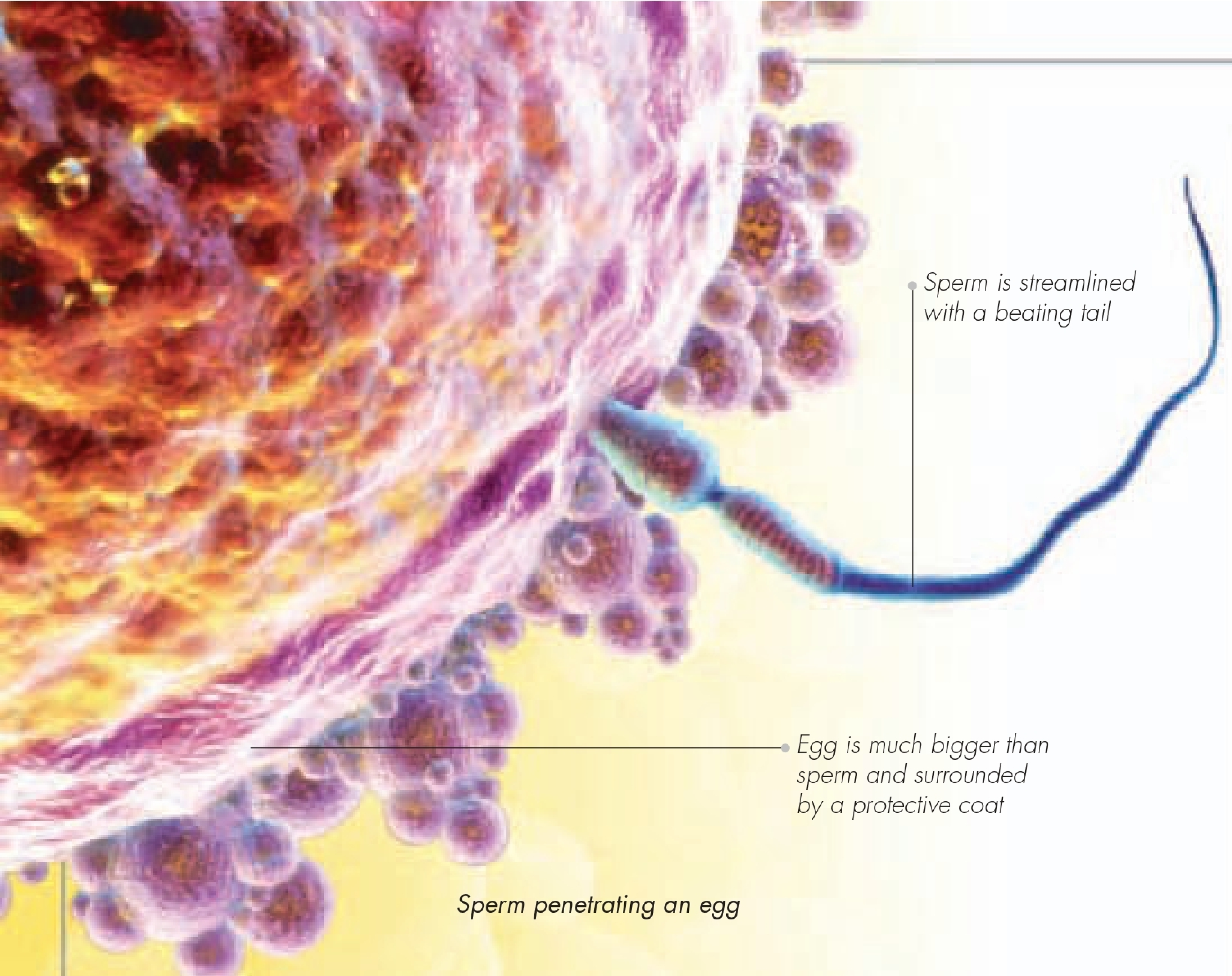
Q

A A built-in repair mechanism acts swiftly to plug leaks from damaged blood vessels. If, for example, you cut yourself and start bleeding, a jelly-like clot forms at the wound site to seal holes in blood vessels. The clot dries out to form a protective scab that stays in place on the skin until the tissues underneath it have been repaired.

Antibodies (blue and pink) surround a bacterium



LIFE STORY



Sperm penetrating an egg

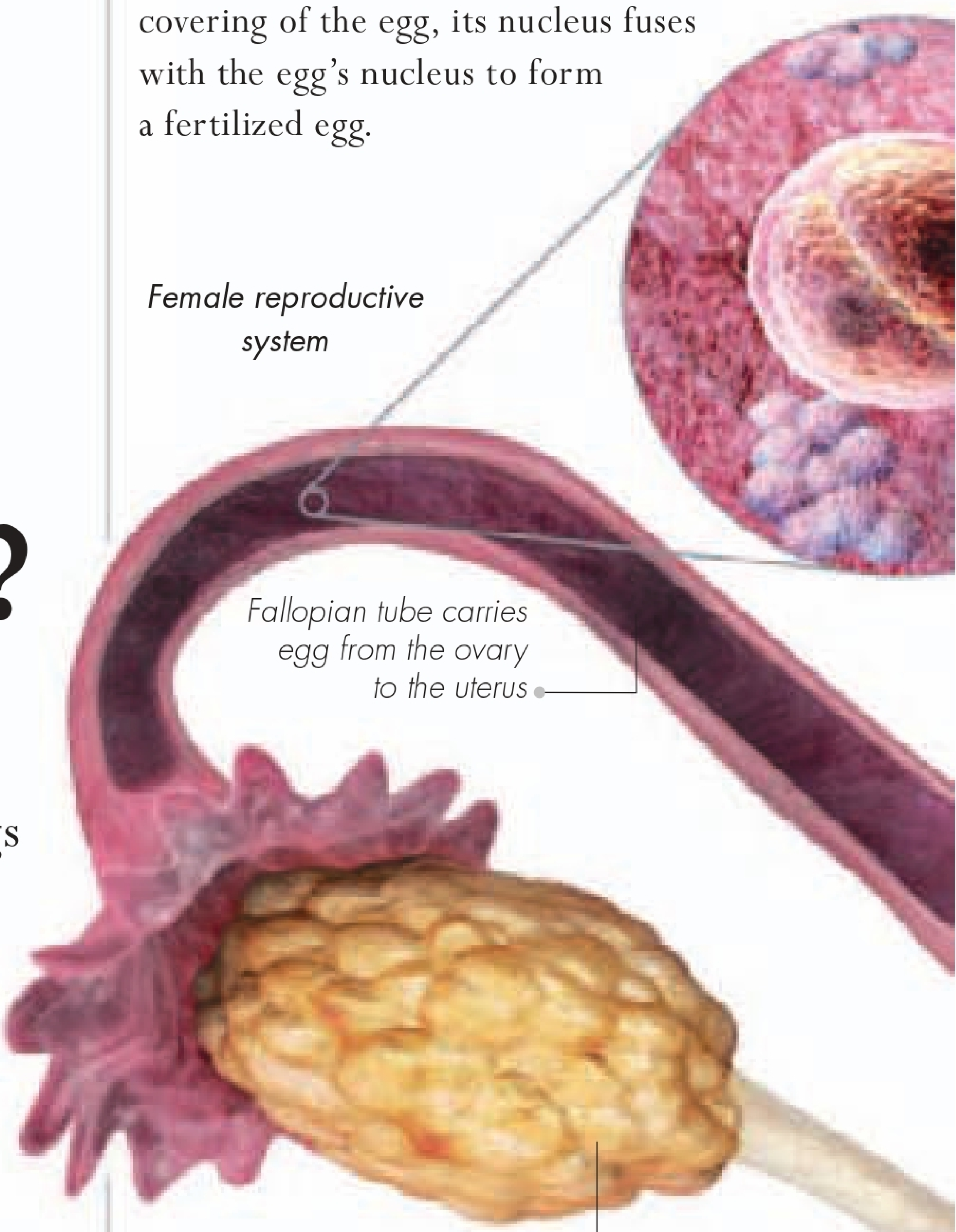
What is fertilization?

The job of the reproductive system is to produce babies. Unlike other body systems, male and female reproductive systems are very different. But, in adults, both produce special sex cells – eggs in women and sperm in men – that contain the genetic material to make a person. If sperm and egg meet and fuse, fertilization occurs. Genetic instructions from both parents combine to produce a new individual. The female reproductive system also provides a safe place for the baby to develop during the nine months of pregnancy.

Q Where does fertilization occur?

A The female reproductive system consists of two ovaries, two fallopian tubes, the uterus, and the vagina – a tube that connects the uterus to the outside. Each month, one of the ovaries releases a mature egg into the fallopian tube. If the egg meets sperm within one day of its release, fertilization will happen. Once a sperm has penetrated the outer covering of the egg, its nucleus fuses with the egg's nucleus to form a fertilized egg.

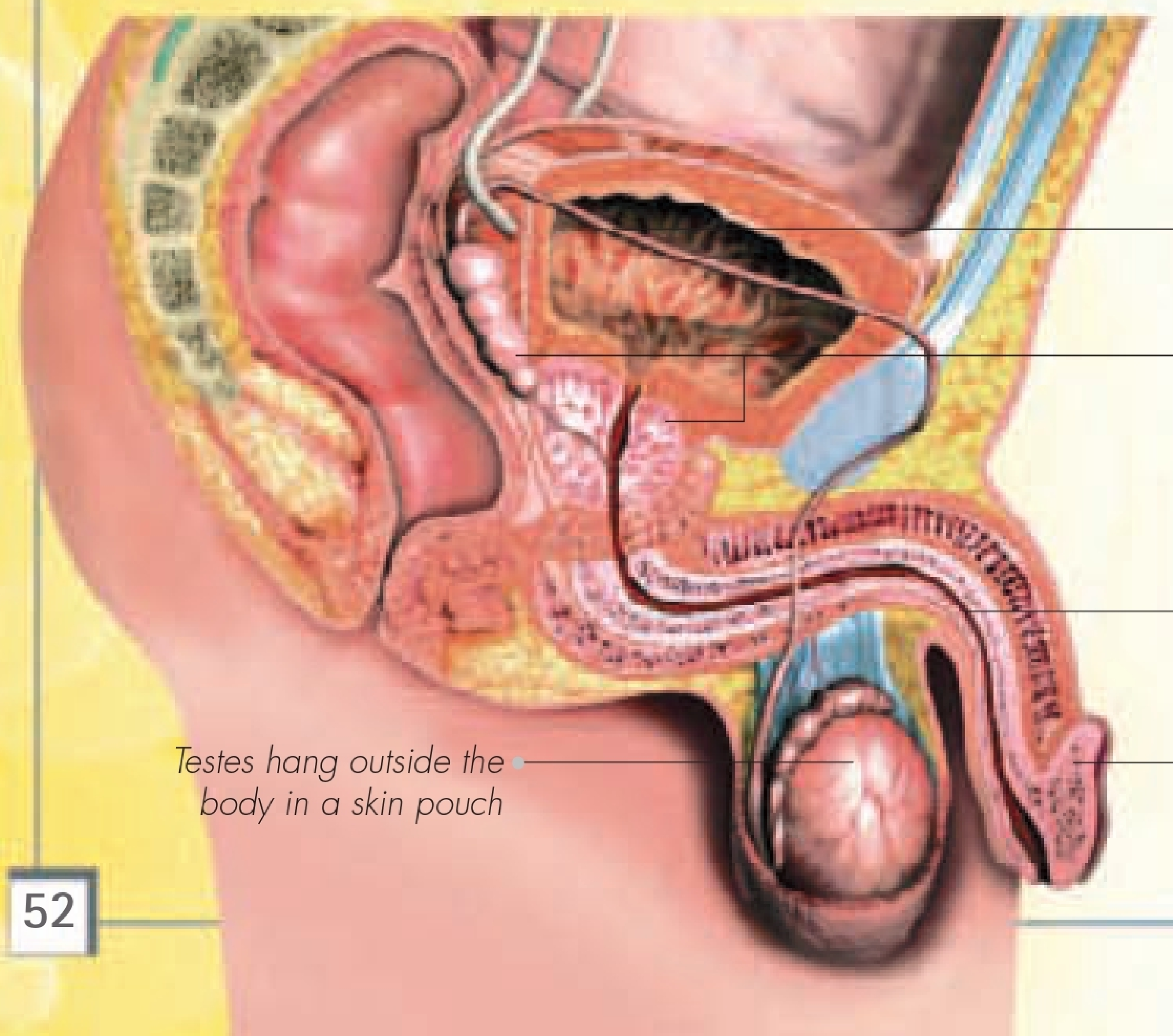
Female reproductive system



Q Where are sperm made?

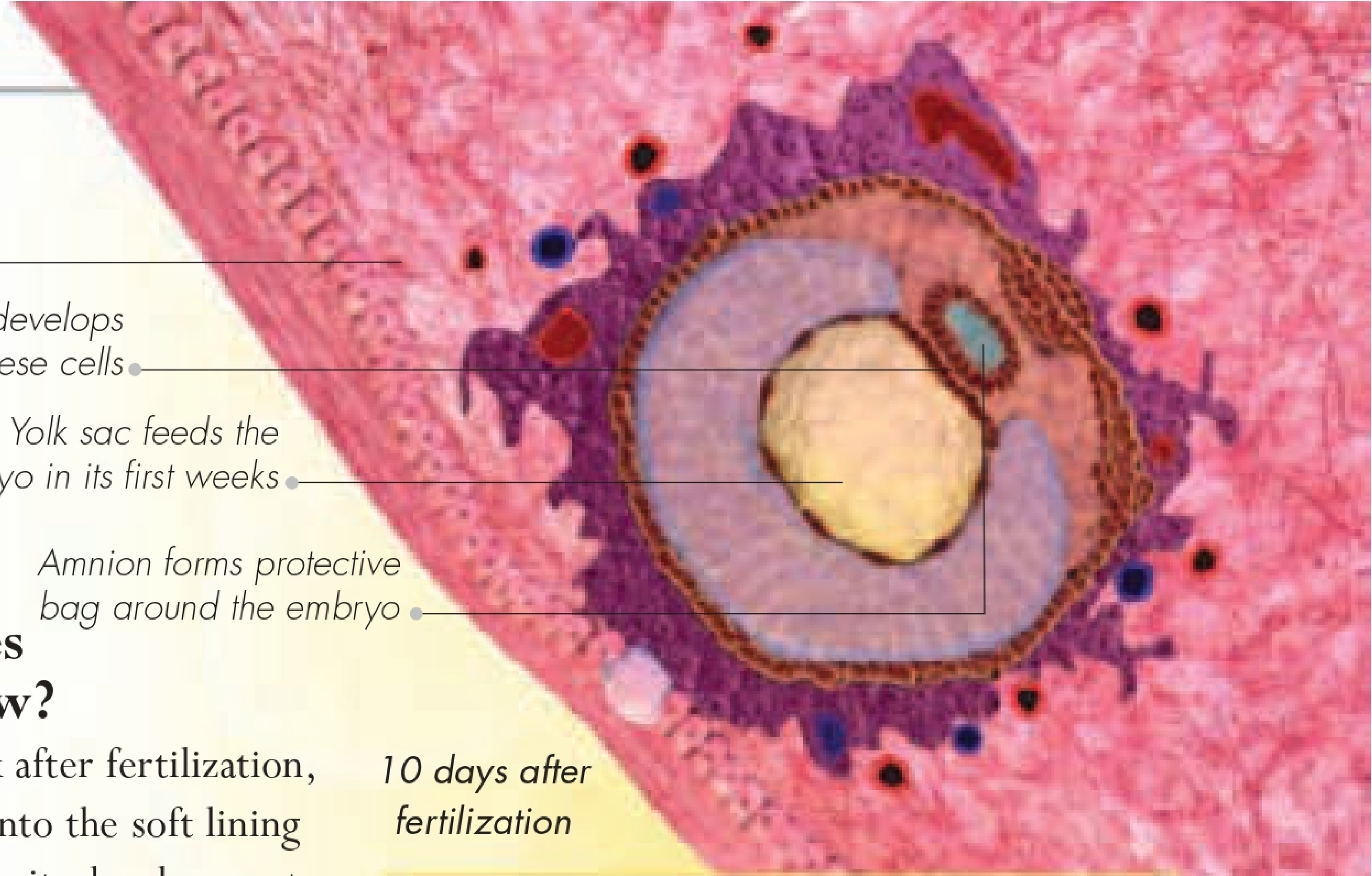
A Males have two plum-sized testes that contain masses of tiny, coiled tubules. These are the sperm "factories" inside which cells divide to produce immature sperm. It takes 20 days for sperm to mature before they are pushed into the ductus deferens – the tube that delivers them to the penis. Together, the testes, penis, and the tubes that link them make up the male reproductive system.

Male reproductive system



What happens next?

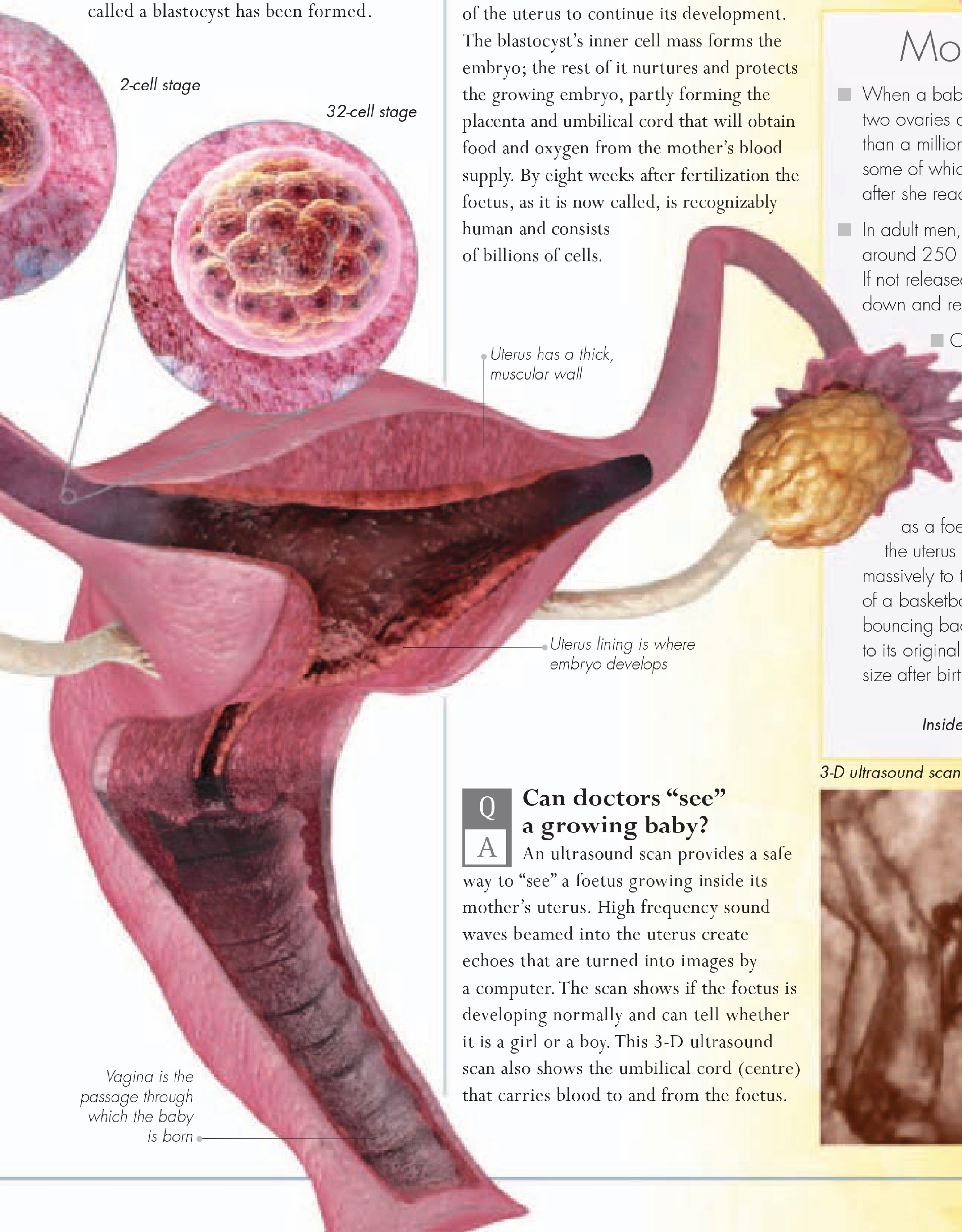
The fertilized egg moves along the fallopian tube towards the uterus. About 36 hours after fertilization, it divides into two identical cells. From then on, division happens every 12 hours, doubling the number of cells present to four, eight, and so on. Four days after fertilization, a ball of 32 cells is ready to leave the fallopian tube. Two days later, inside the uterus, a hollow ball of cells called a blastocyst has been formed.



10 days after fertilization

Where does a baby grow?

Just over a week after fertilization, the blastocyst burrows into the soft lining of the uterus to continue its development. The blastocyst's inner cell mass forms the embryo; the rest of it nurtures and protects the growing embryo, partly forming the placenta and umbilical cord that will obtain food and oxygen from the mother's blood supply. By eight weeks after fertilization the foetus, as it is now called, is recognizably human and consists of billions of cells.



More Facts

- When a baby girl is born, her two ovaries already contain more than a million immature eggs, some of which will be released after she reaches puberty.
- In adult men, the testes produce around 250 million sperm each day. If not released, sperm are broken down and recycled.
- Only a few hundred sperm survive the journey to the fallopian tube.
- The uterus normally resembles an upside-down pear. But during pregnancy, as a foetus grows, the uterus expands massively to the size of a basketball, bouncing back to its original size after birth.

Inside a uterus

Can doctors "see" a growing baby?

An ultrasound scan provides a safe way to "see" a foetus growing inside its mother's uterus. High frequency sound waves beamed into the uterus create echoes that are turned into images by a computer. The scan shows if the foetus is developing normally and can tell whether it is a girl or a boy. This 3-D ultrasound scan also shows the umbilical cord (centre) that carries blood to and from the foetus.

3-D ultrasound scan

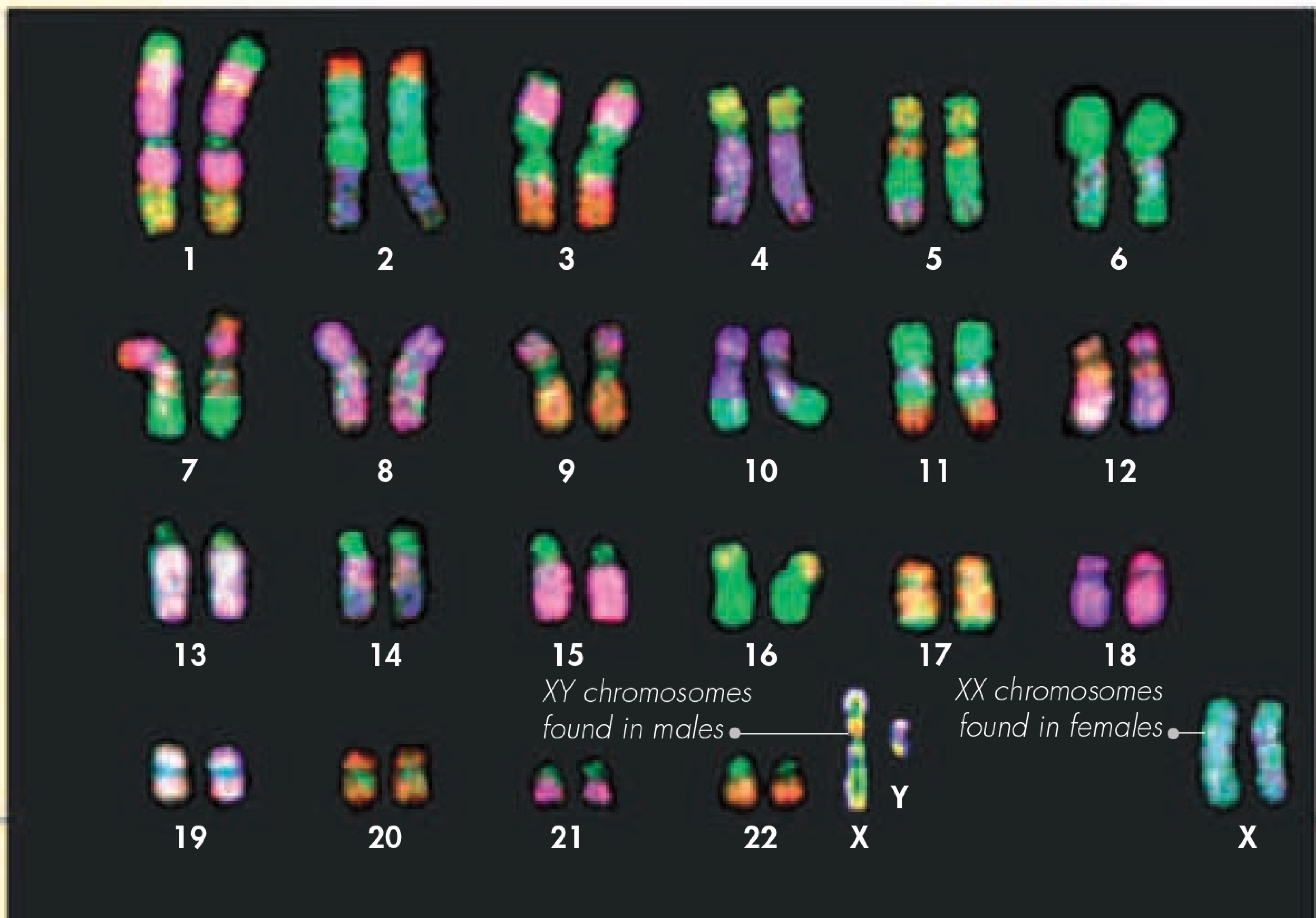
How are identical twins the same?

The nucleus of every body cell contains structures called chromosomes that are made from DNA. This master molecule holds the instructions that make you look human but also give you individual features that make you stand out from the crowd. You inherit DNA from both your parents. When humans reproduce, slightly different DNA instructions from each parent come together in the fertilized egg to create a unique individual. Occasionally a fertilized egg splits into two separate cells. These develop into twin babies that look identical because they share exactly the same DNA.

Q How many chromosomes do I have?

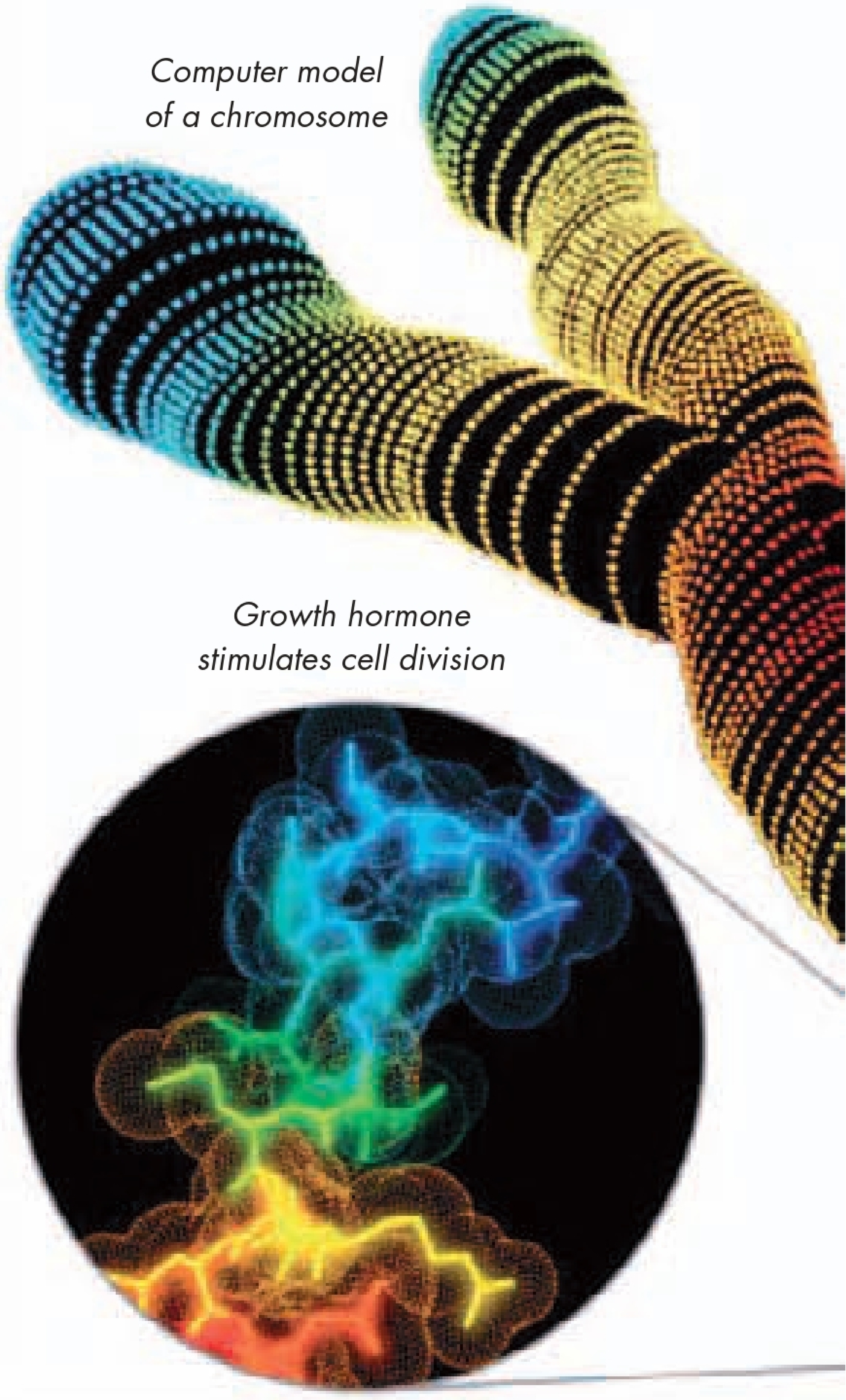
A There are 23 pairs of chromosomes inside a body cell, which are here arranged and numbered in order of size from 1 (longest) to 22 (shortest). The 23rd pair is the sex chromosomes – XY in males and XX in females – which determine a person's sex. One member of each chromosome pair comes from your mother and one from your father. When a man's sperm and a woman's egg fuse at fertilization, each contributes 23 chromosomes, making 46 chromosomes in the fertilized egg that develops into a baby.

Human chromosomes



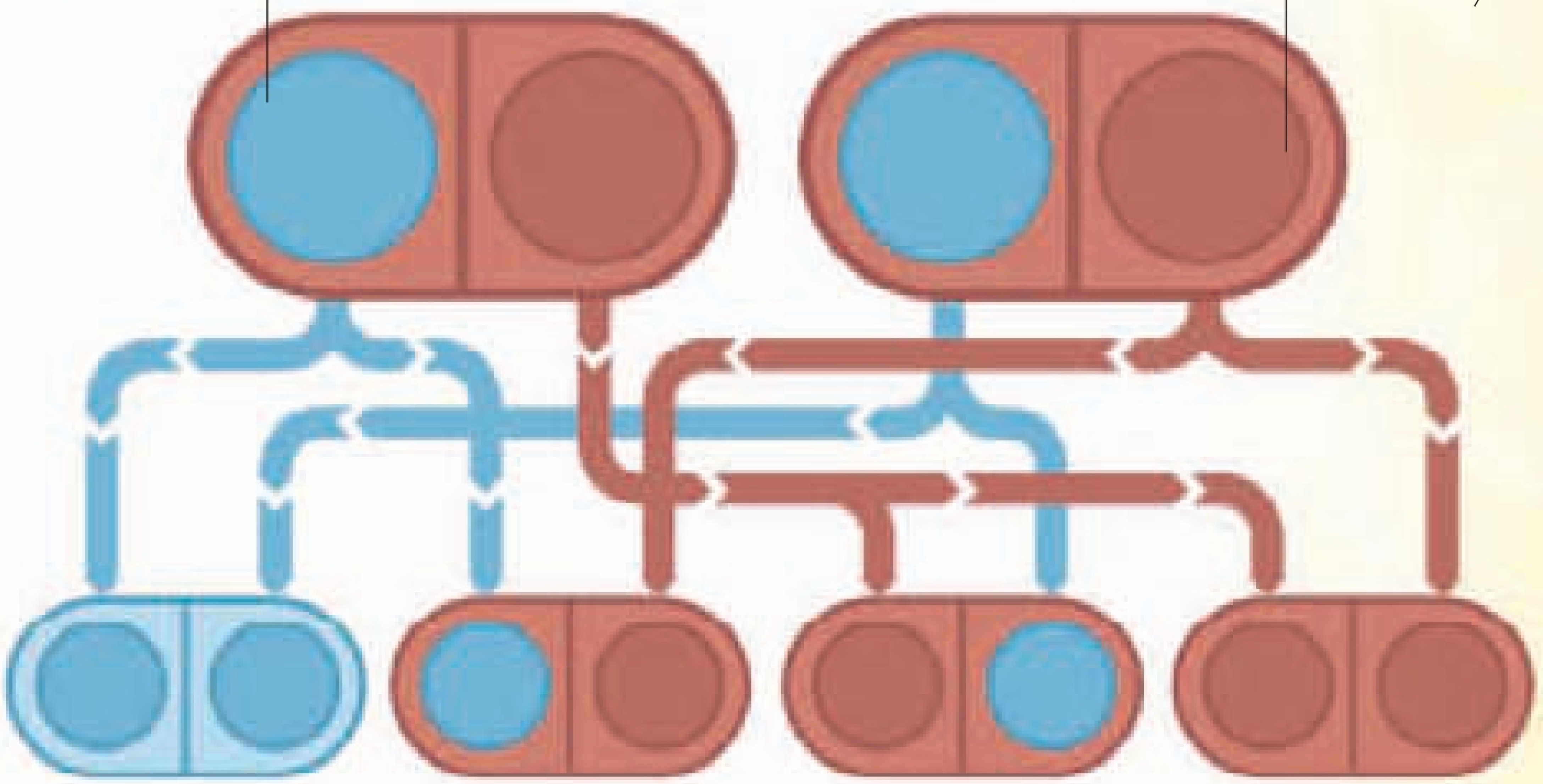
Q What are genes?

A A set of 23 chromosomes contains the instructions, called genes, required to build and run cells and, therefore, the human body. Every chromosome carries many genes. Each gene consists of a short section of the long, coiled DNA molecule that makes up the chromosome. A gene's DNA holds the coded information needed to make one of the many proteins that make your body work.



Computer model of a chromosome

Growth hormone stimulates cell division



Q Why don't I look the same as my parents?

A Both chromosomes – one from each parent – in a pair contain the same genes, although one of the chromosomes in the pair may carry different versions, or alleles, of those genes. While one allele (dominant) will always have an effect on the person's make-up, the other one (recessive) won't unless it is present on both chromosomes. That's why you could have blue eyes when both your parents have brown eyes.

Reading the genome

A tongue roller

Q Why can some people roll their tongue?

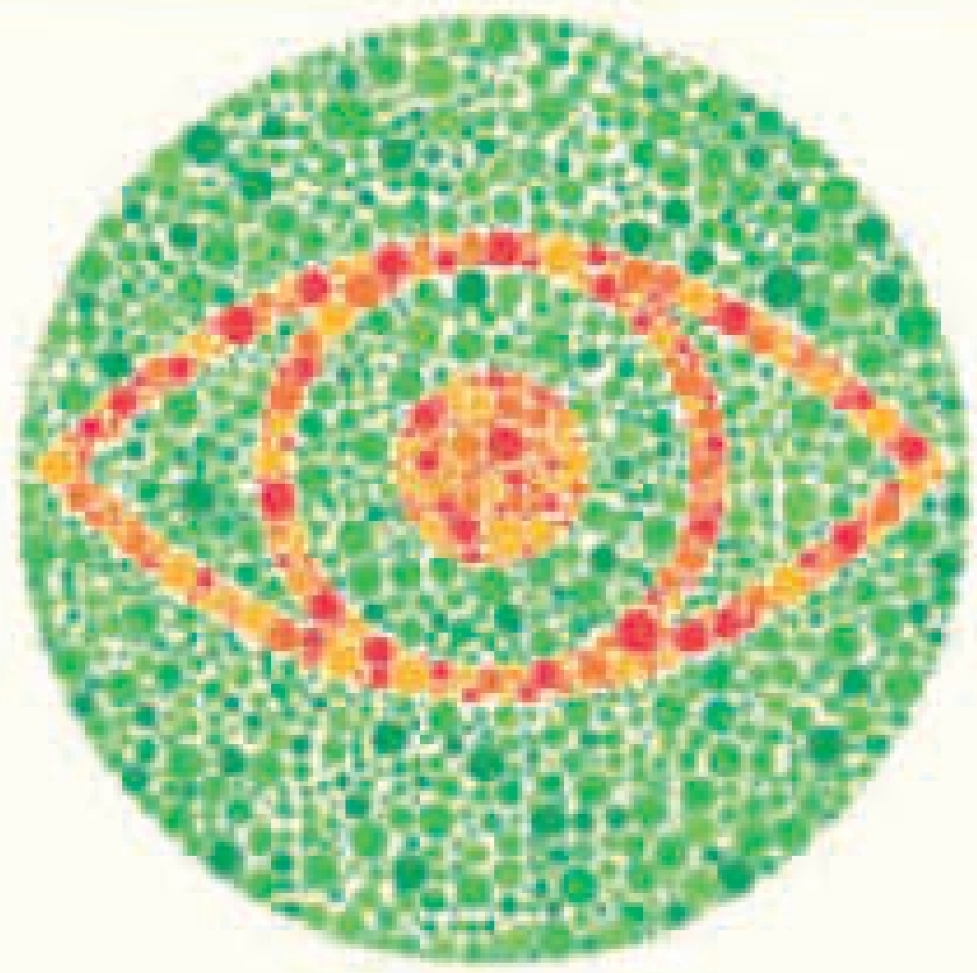
A Most of your features are each controlled by several genes. But a few depend on a single gene, including being able – or not – to roll your tongue like this. If you inherit the dominant tongue-rolling allele (version) of the gene from one or both parents, you can roll your tongue. But if you inherit the non-tongue-rolling allele from both parents, you can't.

Q What was the Human Genome Project?

A The human genome is all the DNA contained in one set of 23 chromosomes. During the Human Genome Project (1990–2003), scientists around the world discovered the sequence of the "letters" in DNA molecules that make up the "words" of the instructions (genes) that control our cells. They did this by breaking up DNA molecules to "read" the "letters" in order. This also allowed them to locate the position of genes on chromosomes.

More Facts

- There were once believed to be 100,000 genes in the human genome. The Human Genome Project suggests there are only 20,000–25,000.
- Stretched out, the DNA in the chromosomes of one tiny cell would extend more than 2 m (6.5 ft). All the DNA in your body would extend across 200,000,000,000 km (124 billion miles).
- If you can't see an eye shape here, you are probably colour blind, meaning that you can't distinguish certain colours. This is caused by a gene carried on the X sex chromosome. Boys have just one X chromosome so if they inherit the gene they are colour blind. But to become colour blind, girls have to inherit the gene on both of their X chromosomes, which is why it's much rarer in girls.



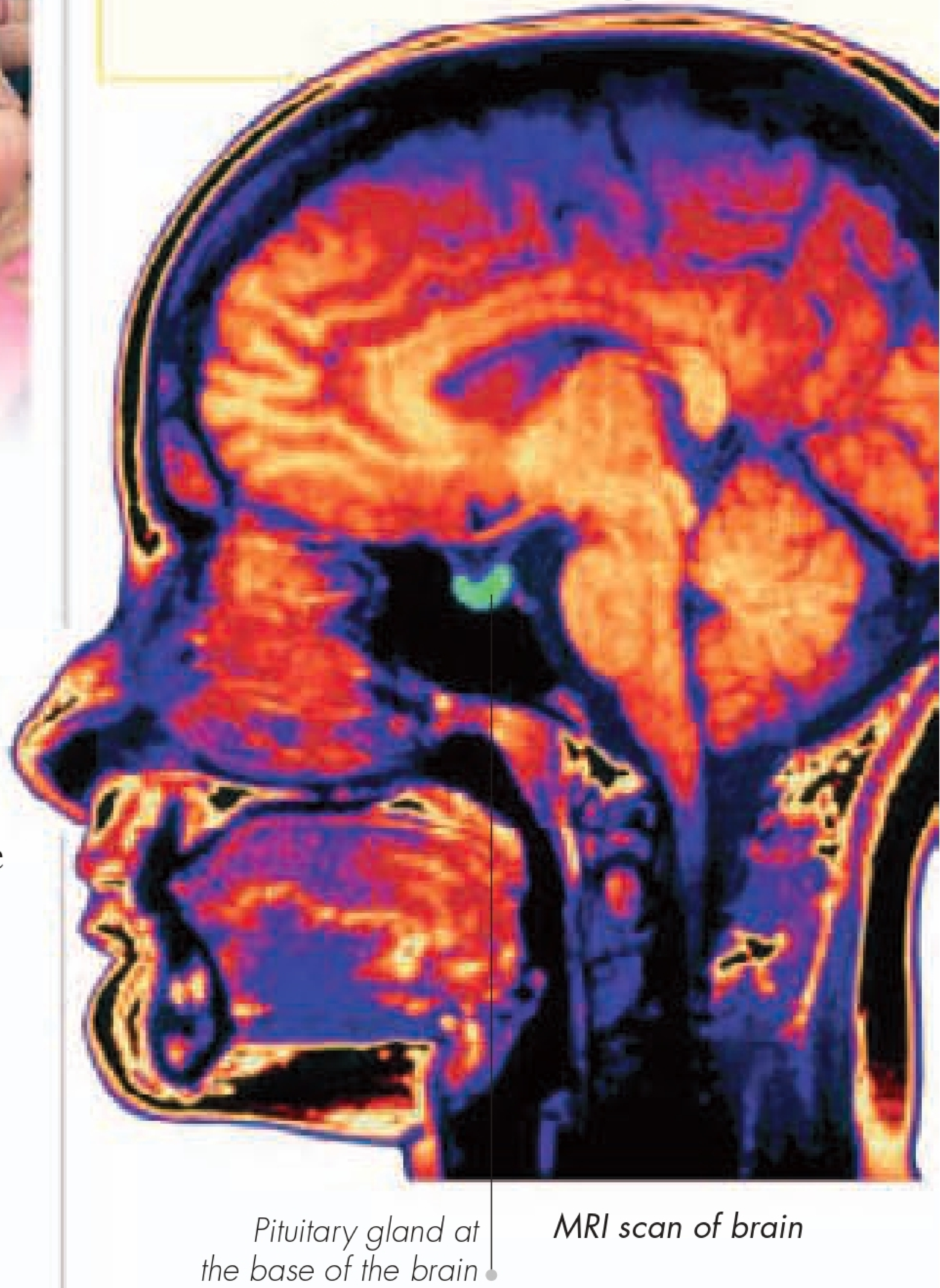
Colour blindness test

Why is my body changing?

As we get older, each of us follows the same sequence of changes. Our bones grow as we do, and our brains become increasingly more complex as we experience the world around us. But perhaps the most dramatic change is during puberty, when children become young adults. Puberty starts in late childhood, earlier in girls than boys. During puberty both girls and boys get taller, their body shapes change, and their reproductive systems "switch on" and start working; girls start having periods and release eggs, while boys start making sperm.

How fast does a child's brain grow?

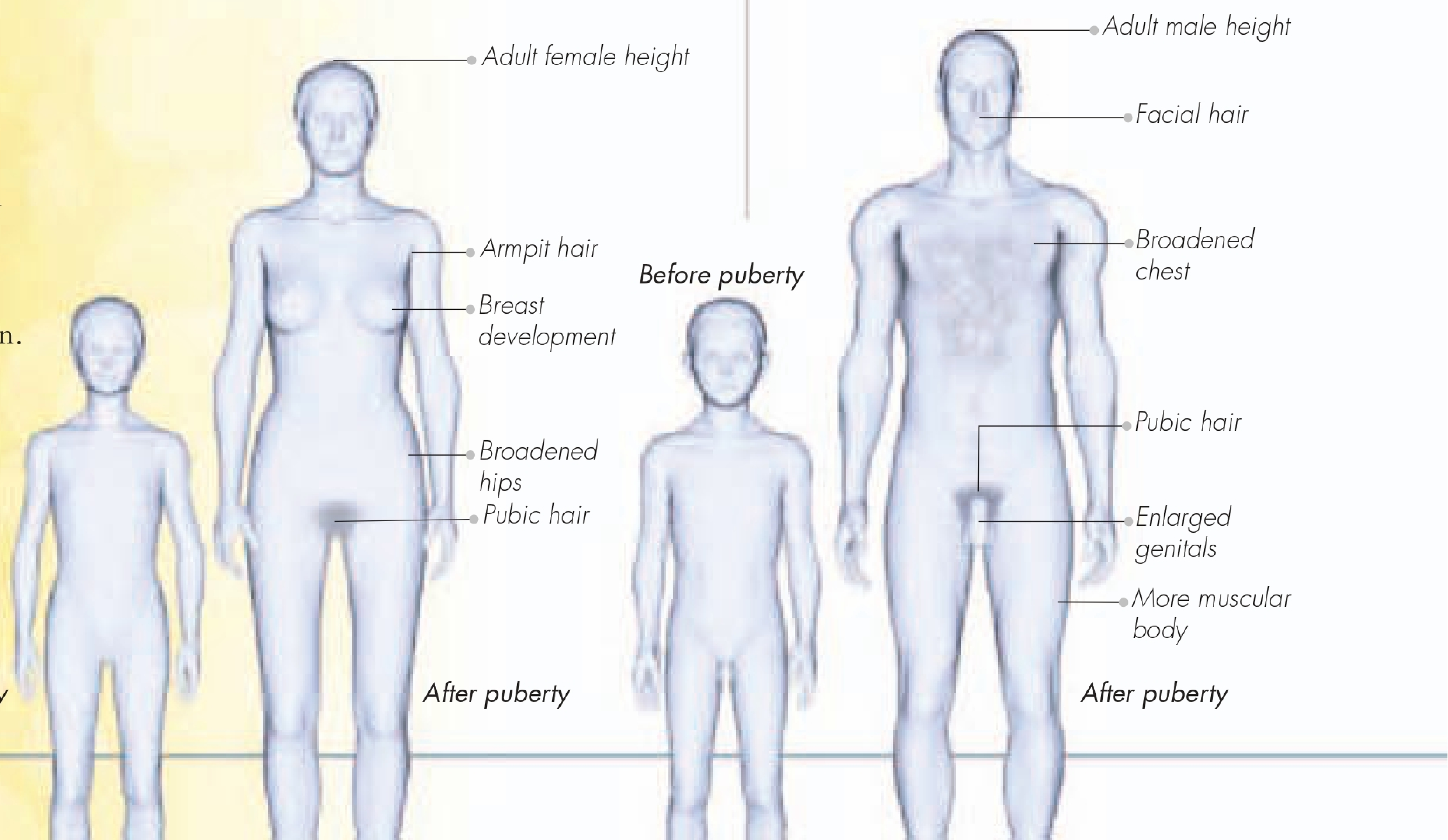
When a baby is born its brain contains the adult complement of 100 billion neurons (nerve cells), but it is just one-quarter the size of an adult's. That is because those neurons have few interconnections and have yet to link up to form the massive network that makes us so smart. Gaps between the skull bones that surround a child's brain allow the brain to expand as the network grows.



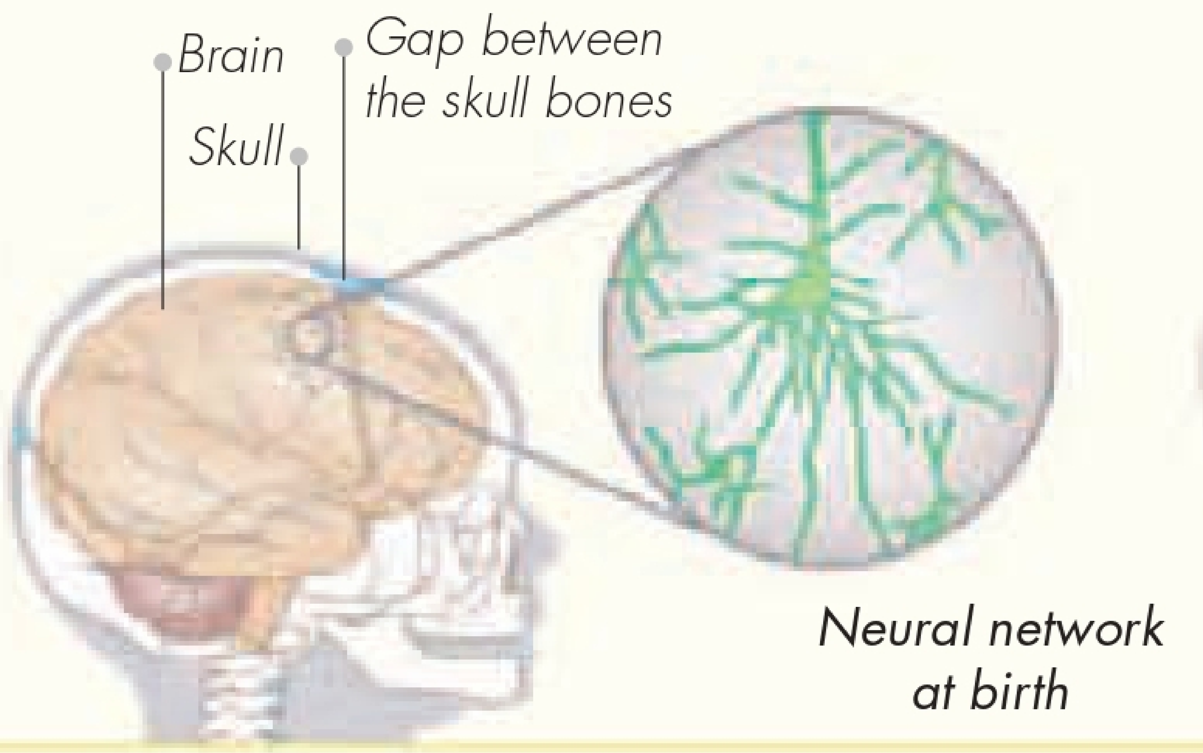
MRI scan of brain

Q What happens to a teen's body?

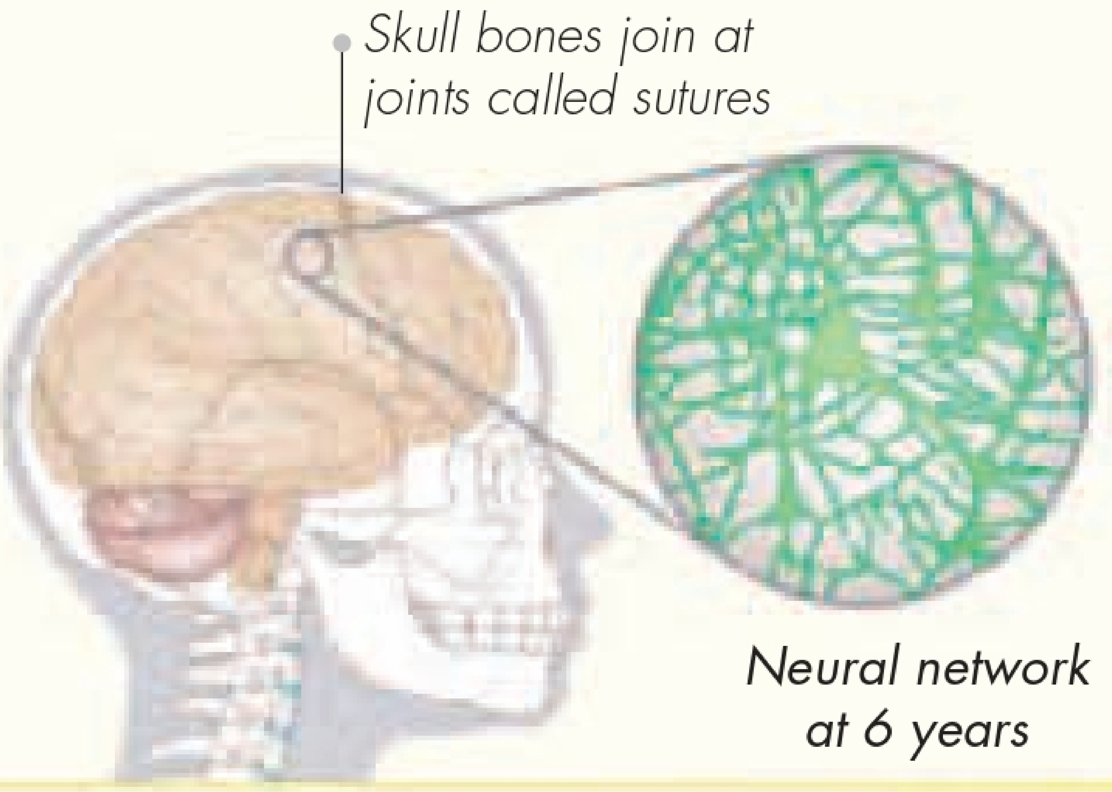
A Both girls and boys show a growth spurt at the same time as their body shapes change to resemble an adult woman or man. A girl's body becomes more rounded and she develops breasts, while a boy's body becomes more muscular. Both sexes grow hair in the armpits and around their genitals.



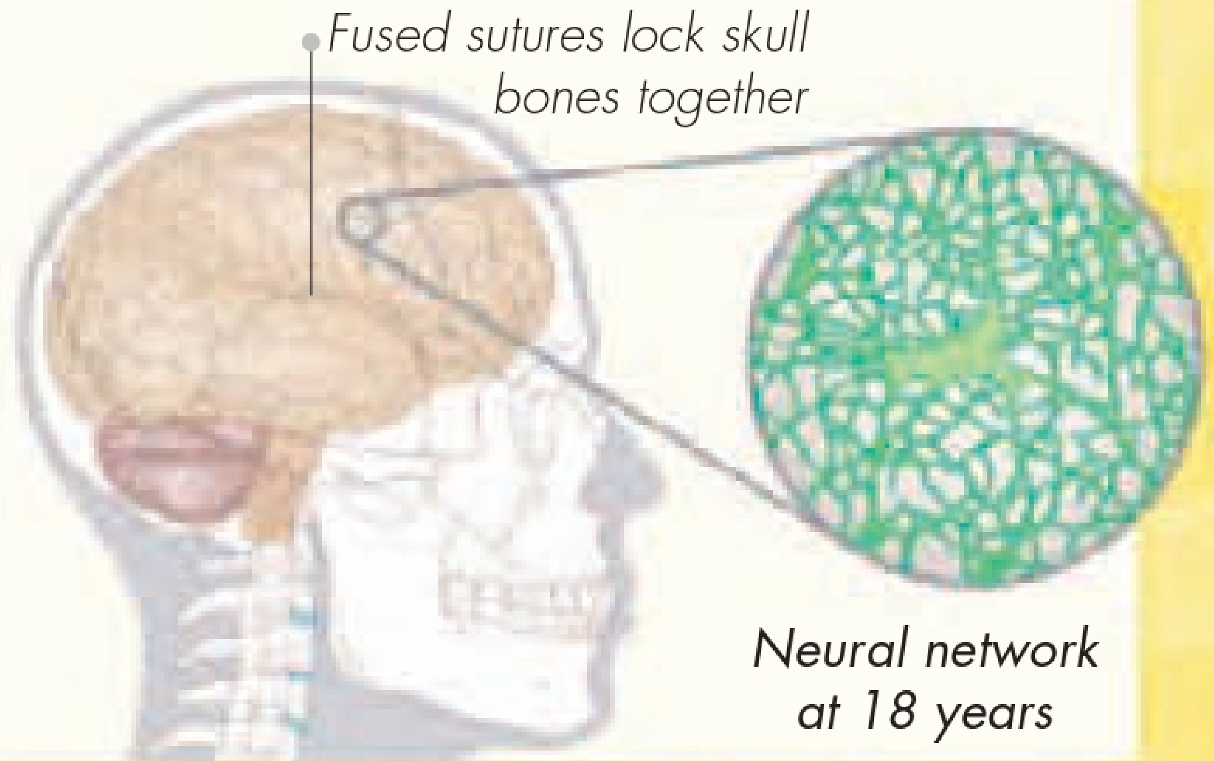
1 Brain neurons (green) have few links between them. Membranes span the gaps between skull bones that allow the brain to expand.



2 As a result of learning and experience, connections between neurons greatly increase, making the brain nearly adult size.



3 The full-sized brain has a complete neural network, and immovable sutures lock the skull bones together.



Q Why does puberty start?

A The events of puberty are started initially by two hormones, released from the pituitary gland. In girls these hormones target the ovaries, causing the release of eggs and of female sex hormones. In males they target the genitals, causing the release of male sex hormones and stimulating sperm production. It is the sex hormones that trigger the changes in girls' and boys' bodies.

Egg (red) released from an ovary

Q What is the menstrual cycle?

A This sequence of events, which repeats itself on average every 28 days, prepares the uterus to receive a fertilized egg. During a menstrual cycle the lining of the uterus thickens and, around day 14, an egg is released from an ovary. If the egg is fertilized it implants in the thick uterus lining. If not, the lining is shed during a period.

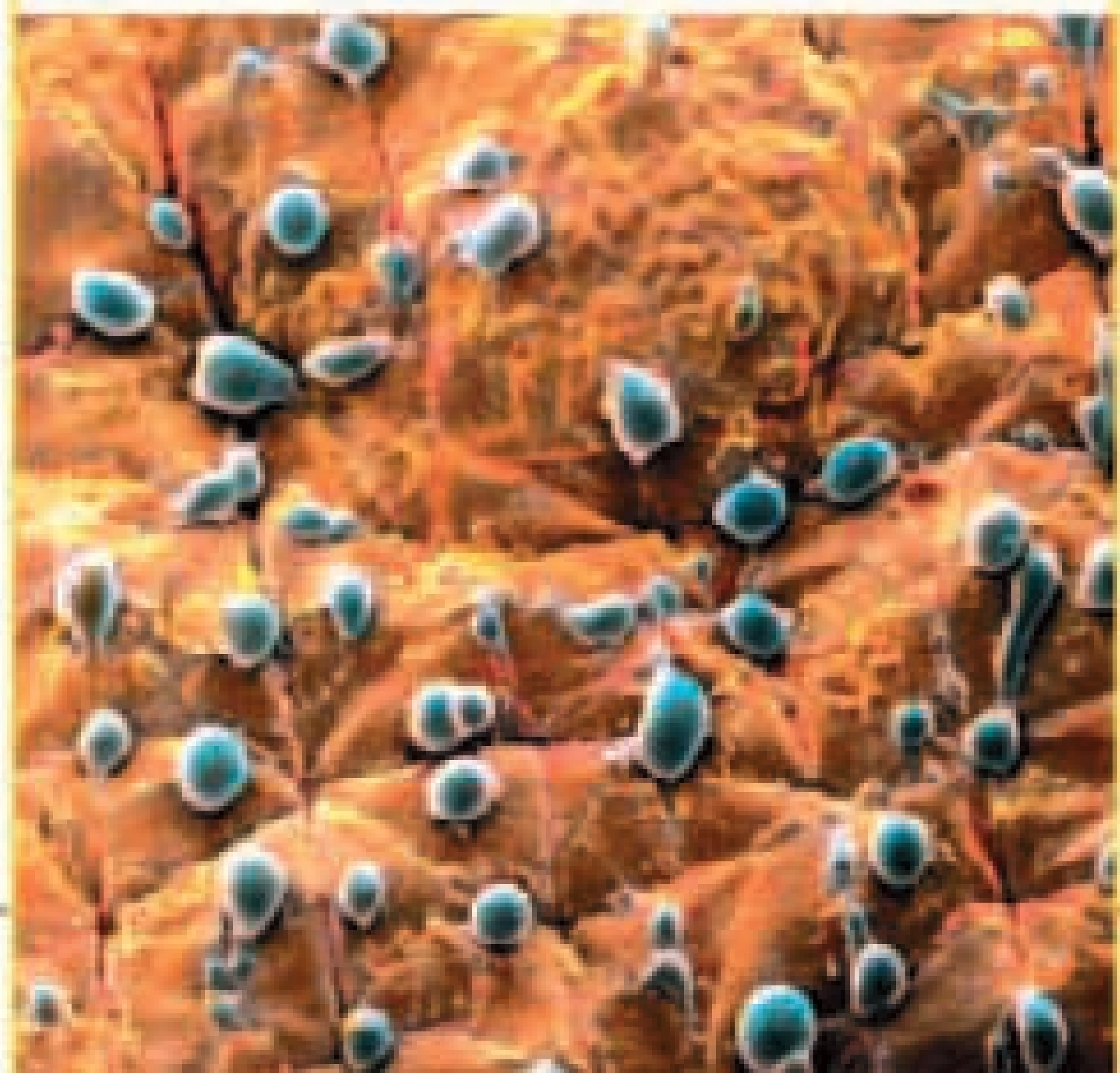
Q How do bones get bigger?

A The skeleton forms as a baby grows in the uterus. At first it is made of flexible cartilage, but gradually this is replaced by harder bone. This process, called ossification, continues into the teenage years, as shown by these two X-rays. In the one-year-old's hand, many "bones" are still largely cartilage – which continues to grow in length. In the 20-year-old's hand, growth and ossification are complete.

More Facts

- In girls, puberty generally begins between the ages of 10 and 12, while in boys it is between 12 and 14.
- Adolescence is the word that describes all the changes to a person, including puberty and changes in behaviour, that are completed by the late teens.
- Special sweat glands in the armpits only start working at puberty. They release a thicker sweat that, when broken down by bacteria, produces body odour.

Sweat on skin



Hand of a 1 year old

Hand of a 20 year old

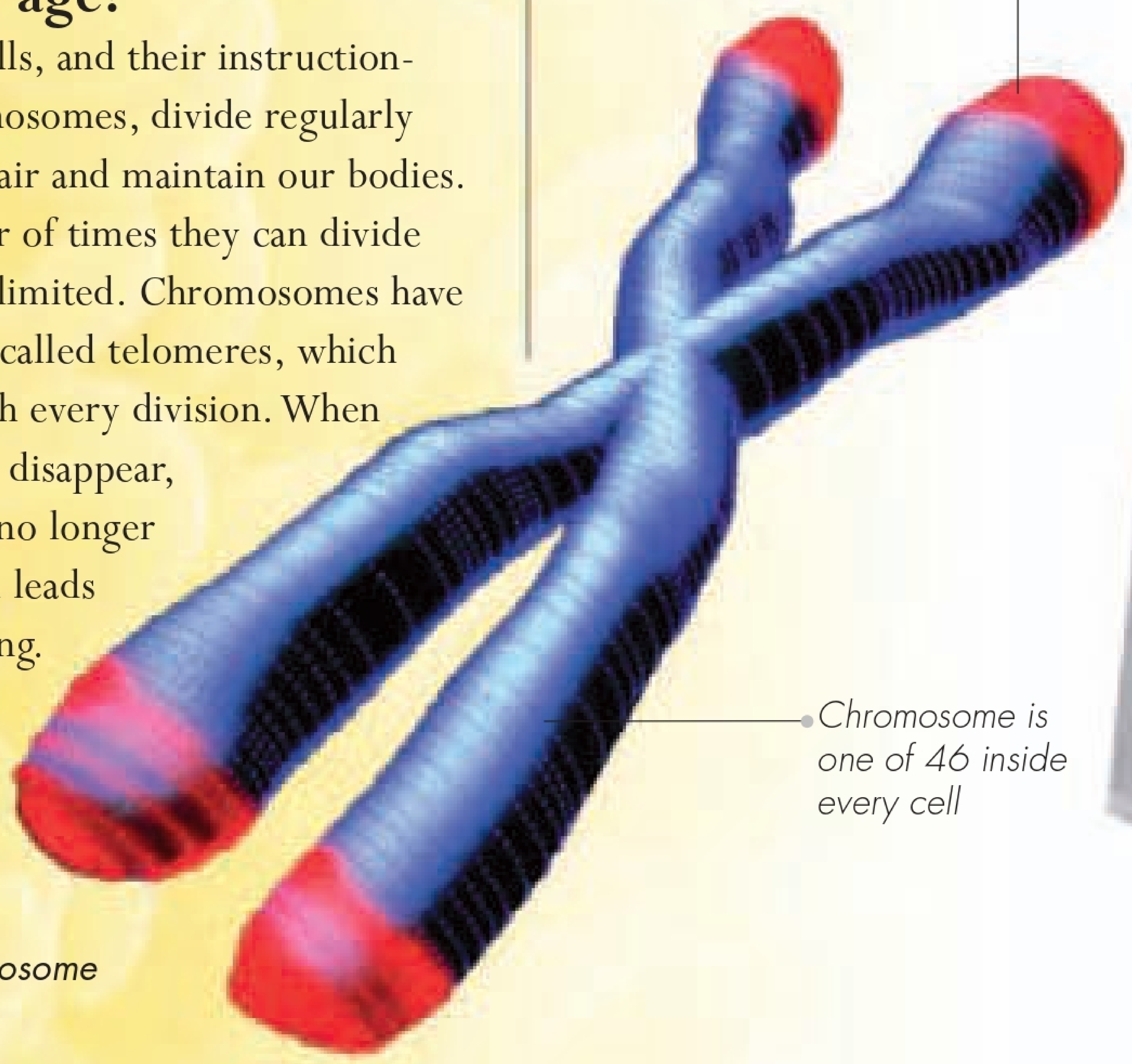
Why don't we live forever?

Ageing and death are natural parts of the human life cycle that are "programmed" into our cells. By the time we reach our 60s, the first signs of wear and tear appear. The skin wrinkles, hair thins and whitens, eyesight and hearing can get worse, thinking slows down, and we get more aches and pains. But many changes can be kept at bay by a good diet and by regular exercise, such as the gentle movements of t'ai chi.

Practising t'ai chi

Q What makes our body age?

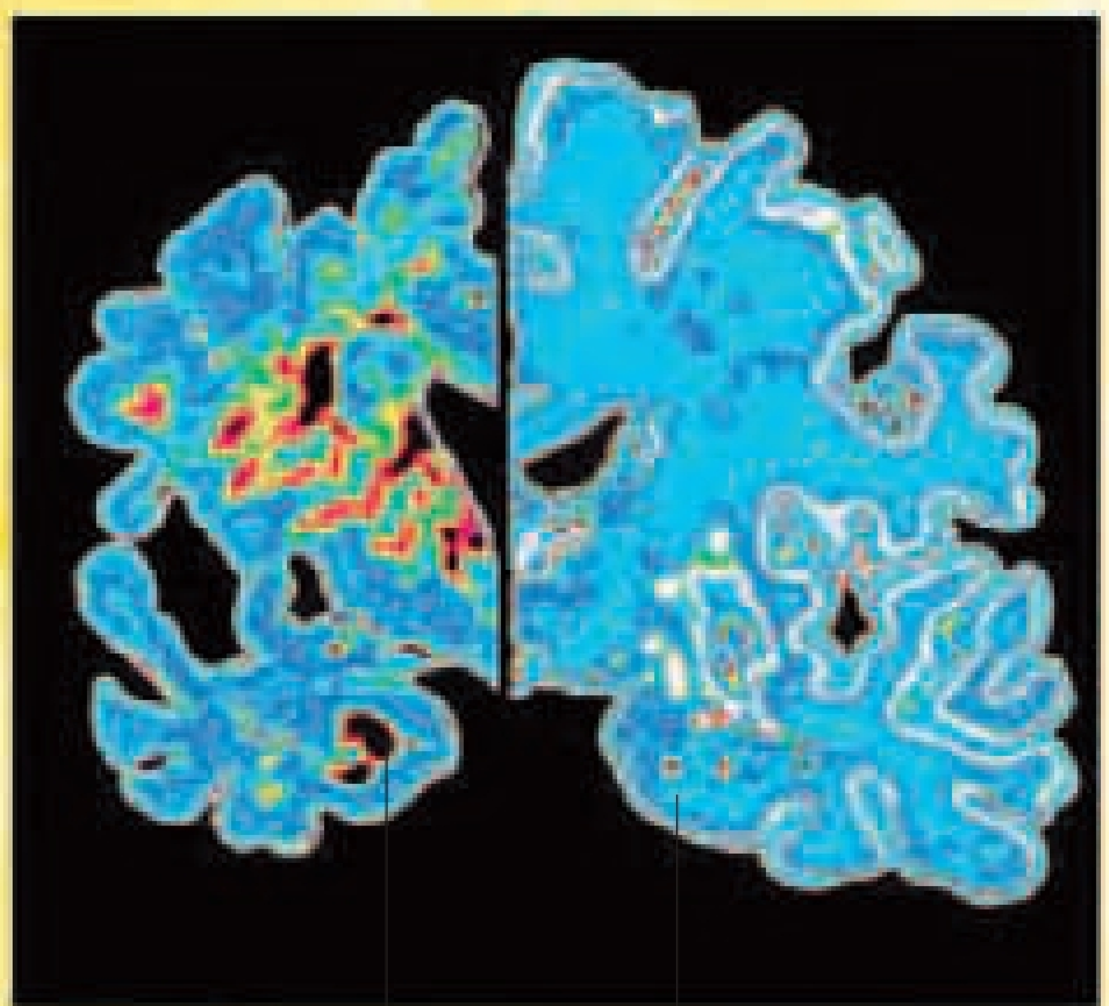
A Our cells, and their instruction-carrying chromosomes, divide regularly in order to repair and maintain our bodies. But the number of times they can divide in a lifetime is limited. Chromosomes have protective tips called telomeres, which get shorter with every division. When they eventually disappear, cell division is no longer possible, which leads to signs of ageing.



Telomeres cap the ends of a chromosome

Chromosome is one of 46 inside every cell

Chromosome



Brain section with Alzheimer's

Healthy brain section

Q Does everyone lose their memory as they get older?

A It isn't inevitable. Although the loss of nerve cells in old age usually make thinking and reaction times slower and memory less efficient, keeping the mind active helps reverse these changes. But people who develop dementia – the commonest form of which is Alzheimer's disease – suffer dramatic brain shrinkage, causing memory loss and confusion that are not reversible.

Jeanne Calment (1875–1997) – the oldest person ever

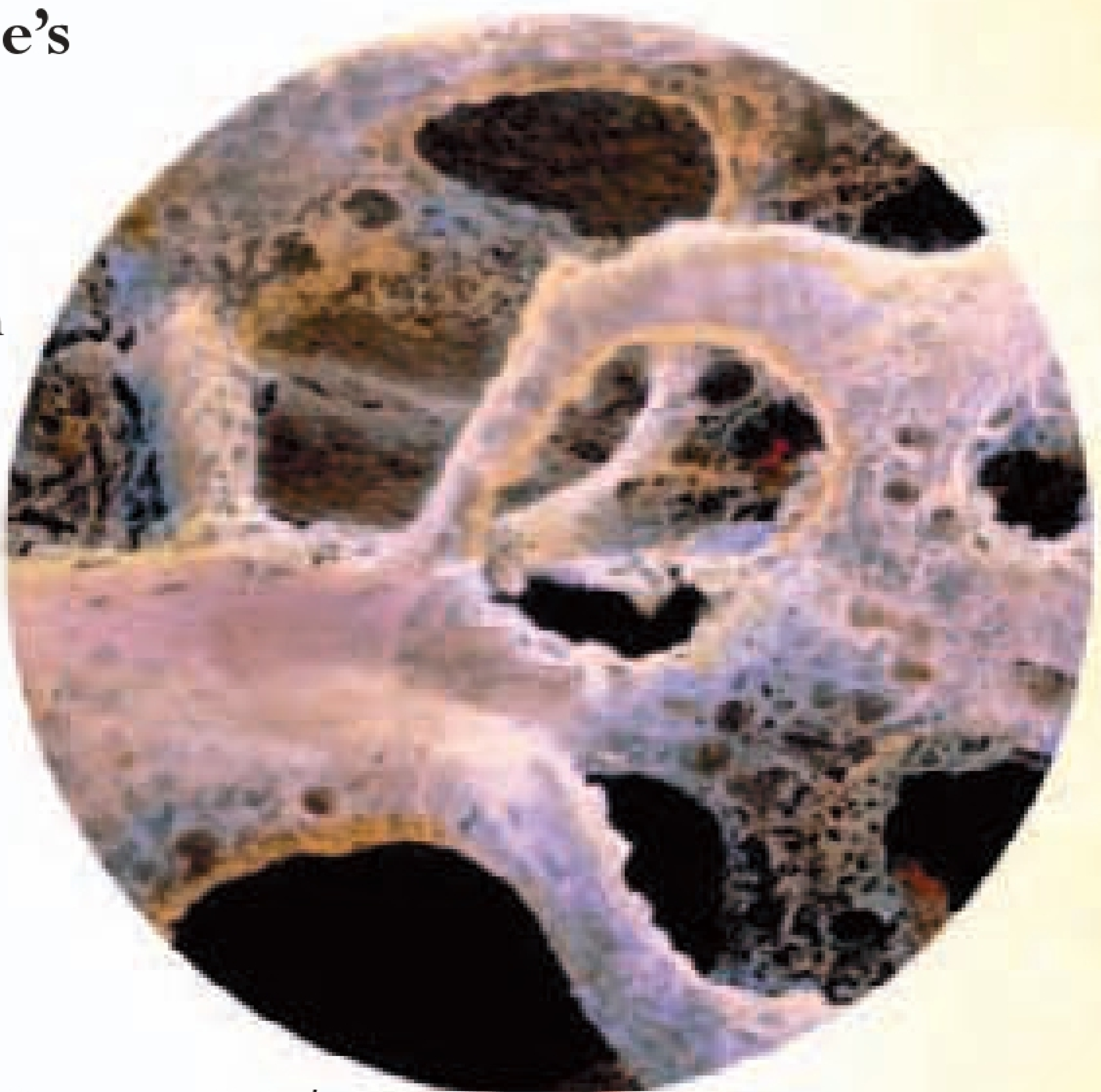
Q A What makes our skin wrinkly?

One of the most visible signs of ageing is wrinkly skin. Young skin is kept strong and stretchy by fibres of collagen and elastin. With age, though, skin gets thinner, produces less protective oil, and the number of collagen and elastin fibres in it decrease. That's why older skin is looser and wrinklier.

Replacement hand with moving parts

Q A Why do older people's bones break more easily?

Throughout life our bones constantly reshape themselves by breaking down and rebuilding themselves. As we age, bone breaks itself down faster than it can be replaced. This makes bones less dense and weaker so that they fracture more easily. Loss of bone density is most dramatic in osteoporosis, a condition found mainly in older women. In addition, joints between bones tend to get stiffer with age.



Osteoporosis in bone

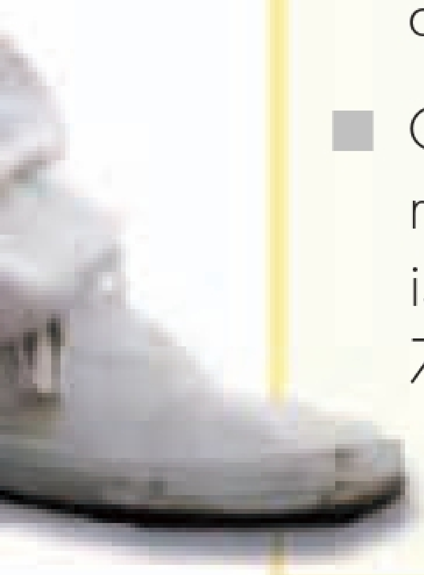
Q A Can we replace body parts?

If we lose a hand, leg, or other body part, either through disease or accident, it will not grow back. But it can probably be replaced. This bionic hand, for example, is "wired up" so that the fingers move as instructed by its owner's brain. This enables it to grip a pen just like a normal hand. Internal organs, such as kidneys or the heart, that have been damaged or are diseased can be replaced by healthy organs provided by donors.

More Facts

- Most of us will live for much longer than our ancestors because we have better diets, live in cleaner, healthier surroundings, and receive superior medical care.
- On average, women live longer than men. Life expectancy in the western world is about 83 for women and 78 for men.
- Men can produce sperm for a lifetime, but women stop releasing eggs at the time of the menopause, which occurs, on average, at the age of 51.
- Skin that is damaged may soon be able to be replaced by artificial skin grown in the laboratory. It would be made with a patient's own cells so that it is not rejected by the patient's body.

Artificial skin



INDEX

CREDITS

Dorling Kindersley would like to thank Caitlin Doyle for proof-reading and Jackie Brind for the index.

The publisher would like to thank the following for their kind permission to reproduce their photographs:

(**Key:** a-above; b-below/bottom; c-centre; l-left; r-right; t-top)

2-3 Corbis: Photo Quest Ltd / Science Photo Library. **4 Corbis:** Steve Gschmeissner / Science Photo Library (bl); Visuals Unlimited (cl) (tl). **4-7 Corbis:** Visuals Unlimited (background). **5 Corbis:** Steve Allen / Brand X (cr); Visuals Unlimited (br). Getty Images: Spike Walker (tr). **6 Corbis:** Kurt Kormann (cl); Photo Quest Ltd / Science Photo Library (tl). **Getty Images:** Sandra Baker (bl). **7 Corbis:** Visuals Unlimited (tc). Getty Images: Steve Gschmeissner / Science Photo Library (bl); Dr. Kessel & Dr. Kardon / Tissues & Organs (br). **8-9 Science Photo Library:** Steve Gschmeissner. **10 Science Photo Library:** Simon Fraser (cr). **10-19 Corbis:** Visuals Unlimited (background). **11 Science Photo Library:** (br); A. Dowsett, Health Protection Agency (c); Prof. P. Motta / Dept. Of Anatomy / University "La Sapienza", Rome (tl). **12 Science Photo Library:** Dr Jeremy Burgess (cl); L'oreal / Eurelios (tl). **13 Science Photo Library:** Steve Gschmeissner (tl) (cr). **15 Science Photo Library:** Dept. Of Clinical Radiology, Salisbury District Hospital (cr); Andrew Syred (tc). **16 Science Photo Library:** Don Fawcett (bc). **17 Corbis:** (cr). **Getty Images:** Mike Kemp (cl). **18 Corbis:** Wally McNamee (c). **19 Corbis:** Dan McCoy - Rainbow/ Science Faction (bc). **Science Photo Library:** DU Cane Medical Imaging Ltd (cr); Zephyr (br). **20-21 Corbis:** Dennis Kunkel Microscopy, Inc./ Visuals Unlimited. **22 Corbis:** Dimitri Lundt/ TempSport (cl). **22-29 Corbis:** Visuals Unlimited (background). **23 Corbis:** Image Source (cr). **Science Photo Library:** Dr Tony Brain (bl). **24 Corbis:** MedicalRF.com (cra); Science Photo Library/ Photo Quest Ltd (cl) (cr). **24-25 Getty Images:** 3D4Medical.com. **25 Corbis:** Dennis Kunkel Microscopy, Inc./ Visuals Unlimited (bc); Reuters (cr). Science Photo Library: BSIP GEMS / Europe (tc). **26 Corbis:** Oliver Rossi (tl). Getty Images: Nucleus Medical Art, Inc. (bl). **27 Getty Images:** Jupiterimages (c). Science Photo Library: Dr Gary Settles (tc); Eye Of Science (cl). **28 Corbis:** Visuals Unlimited (c). **Science Photo Library:** (bl) (bc). **29 Corbis:** Mod Art / CSA Images (tc); Roy Hsu/ Blend Images (br). **30-31 Getty Images:** Thomas Deerinck. **32-39 Corbis:** Visuals Unlimited (background). **33 Alamy Images:** Chuck Franklin (tc). **Getty Images:** Iconica / Brick House Pictures (bc). **National Geographic Stock:** Cary Wolinsky (cr). **Science Photo Library:** Steve Gschmeissner (clb); C. J. Guerin, PHD, MRC Toxicology Unit (cl). **34 Science Photo Library:** Omikron (bl). **35 Getty Images:** Fabrice Coffrini / AFP (bc). **36 Science Photo Library:** Steve Gschmeissner (bc). **37 Corbis:** Wally McNamee (cr). Getty Images: Digital Vision / James Woodson (c); Workbook Stock / Thierry Grun (bc). Science Photo Library: Susumu Nishinaga (cl). **38 Science Photo Library:** (bl). **39 Corbis:** Amanaimages (bc). **Getty Images:** Iconica / Jeffrey Coolidge (tr); StockFood Creative / Ian Garlick (cr). **Science Photo Library:** Steve Gschmeissner (c). **40-41 Corbis:** Visuals Unlimited. **42 Science Photo Library:** Steve Gschmeissner (br). **43 Science Photo Library:** NIBSC (tl); Antonia Reeve (tr). **44 Getty Images:** Visuals Unlimited / Dr. Fred Hossler (c). **45 Getty Images:** Jasper Juinen (br). **Science Photo Library:** CNRI (cr) (crb); Susumu Nishinaga (c). **47 Alamy Images:** Hugh Threlfall (br). Corbis: Frans Lanting (cr). **Science Photo Library:** Eye Of Science (tc); Roger Harris (c). **48 Science Photo Library:** Pasieka (cra). **48-49 Science Photo Library:** Eye Of Science (bc); NIBSC (tc). **49 Getty Images:** Stockbyte (cb). **Science Photo Library:** David Goodsell (br); Steve Gschmeissner (cr); Dr Gopal Murti (tr). **50-51 Science Photo Library:** Steve Gschmeissner. **52-59 Corbis:** Visuals Unlimited (background). **53 Corbis:** Visuals Unlimited (crb). **Science Photo Library:** GE Medical Systems (br). **54 Corbis:** Tim Pannell (tl). **Science Photo Library:** CNRI (br/XY); Dept. Of Clinical Cytogenetics, Addenbrookes Hospital (br); Pasieka (cr). **54-55 Science Photo Library:** Pasieka. **55 Corbis:** Andrew Brookes (cr). Science Photo Library: David Nicholls (br). **56 Corbis:** Randy Faris (tl). Science Photo Library: Scott Camazine (cr). **57 Science Photo Library:** (br); Professors P.M. Motta & J. Van Blerkom (c); Richard Wehr / Custom Medical Stock Photo (bl). **58 Getty Images:** Mike Kemp (cr). **Science Photo Library:** Pasieka (bl) (c). **59 Corbis:** EPA / Waltraud Grubitzsch (tr); Pascal Parrot (tl). **Science Photo Library:** Mauro Fermariello (br); Prof. P. Motta / Dept. Of Anatomy / University "La Sapienza", Rome (c). **60-61 Corbis:** Visuals Unlimited. **62-63 Corbis:** Photo Quest Ltd/ Science Photo Library

Jacket images: Front: **Science Photo Library:** Susumu Nishinaga (background); Pasieka c (skull). Back: **Corbis:** Jens Nieth bl; Visuals Unlimited cla; **Science Photo Library:** Mehau Kulyk cl; Bill Longcore tl; Susumu Nishinaga clb

HUMAN BODY

What makes blood red?
Do clever people have big brains?
Why is a haircut painless?

Whatever the question, *Human Body* has the answer!

Circulation system

Discover how blood travels round the body and why your heart beats faster when you run

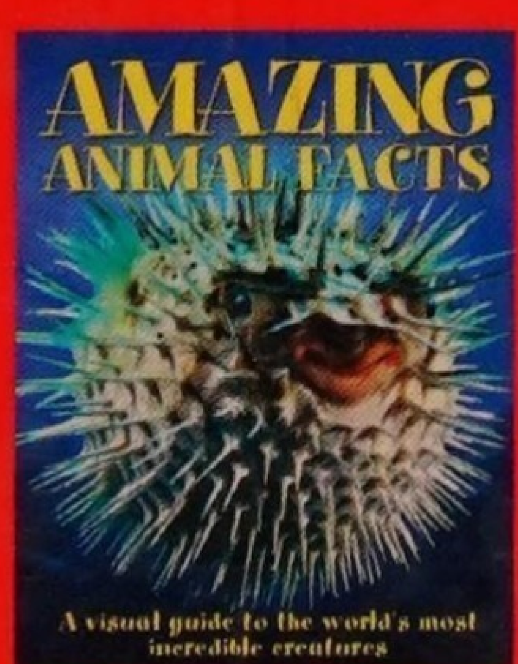
Super senses

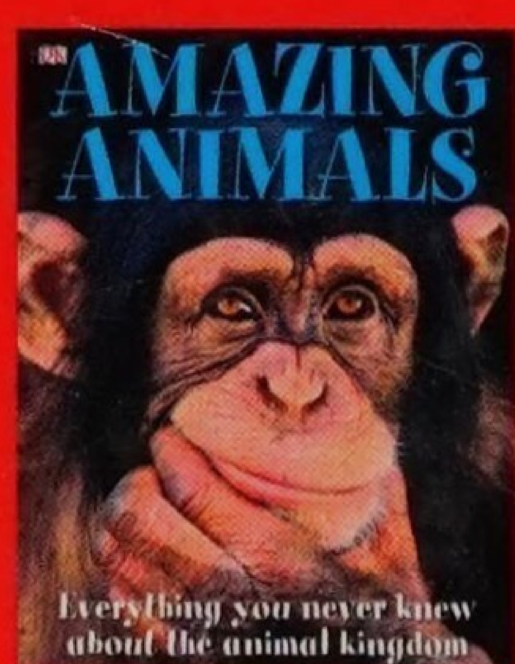
Find out where thoughts come from and how we can see, smell, touch, taste, and hear

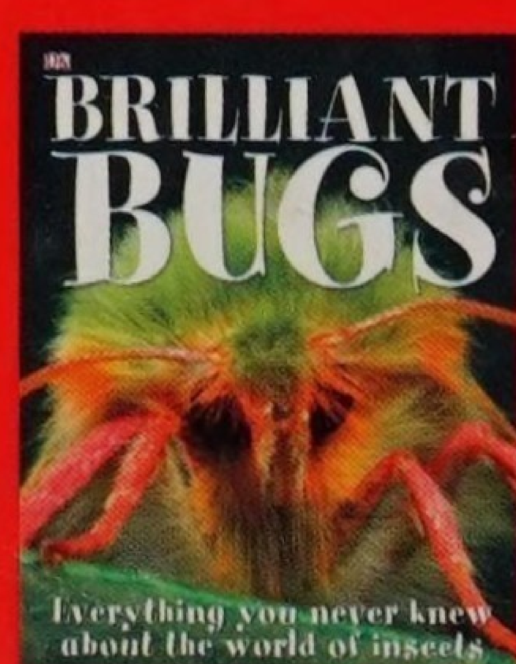
Food processor

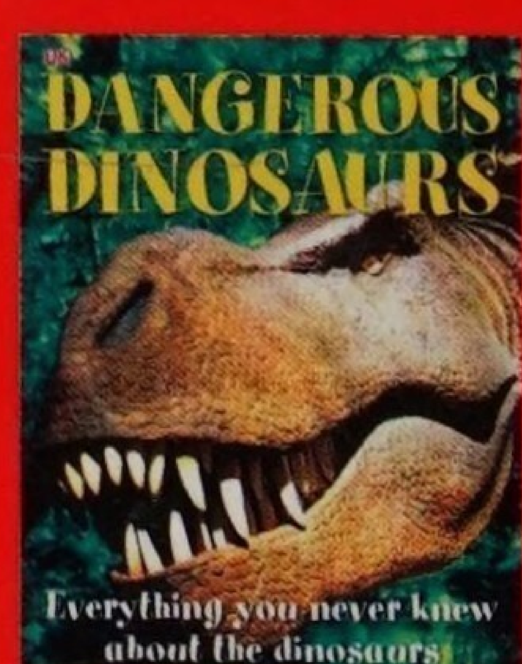
Follow what happens to food as it travels through your digestive system

With fantastic facts and far-out photos, *Human Body* tells the head-to-toe story of what makes you tick.









ALSO AVAILABLE FROM DK

Discover more at
www.dk.com

£7.99

ISBN 978-1-40533-668-0

9 781405 336680